

# Electrochemical and Metallurgical Industry

VOL. VII.

NEW YORK, MARCH, 1909

No. 3

## Electrochemical and Metallurgical Industry

*With which is incorporated Iron and Steel Magazine*

Published Monthly by the

ELECTROCHEMICAL PUBLISHING COMPANY

239 West 39th Street, New York

EUROPEAN OFFICE, Hastings House, Norfolk St., Strand, London, Eng.

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*Yearly subscription price for United States, Mexico and United States dependencies, \$2.00; for all other countries, \$2.50 (European exchange, 10 shillings, 10 marks, 12.50 francs).*

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Entered as Second-Class Matter, June, 1903, at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879

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### The Adoption of the Heroult Furnace by the United States Steel Corporation.

The decision of the United States Steel Corporation to adopt the Héroult electric furnace for steel refining at two of its plants is a matter of more than passing interest and is likely to result in developments of considerable importance. Details of the plans of the Steel Corporation will be found on page 104 of this issue. Here we shall try to emphasize only the points of broadest significance. First, about the size of the furnaces. The largest Héroult steel furnaces installed in the past have a capacity of five tons. The largest steel furnace built anywhere so far (one of the Roehling-Rodenhauser type in Germany) has a capacity of eight tons. The Héroult furnaces of the Steel Corporation will have a capacity of 15 tons. And admittedly this is only a beginning, and the erection of 30-ton furnaces is contemplated when sufficient experience has been gained with the 15-ton size. The development is characteristically American. Our steel masters have patiently waited till all the little details and problems had been worked out in Europe and the tedious experimental stage was passed. Now they are going into the matter not in a half-hearted way, but on a scale untried in Europe. The United States Steel Corporation becomes the daring pioneer of the *big* electric steel furnace.

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The second point of decided novelty is the purpose for which the steel refined in the electric furnace is intended to be used. In the two American steel works in Syracuse and McKeesport where Héroult furnaces have been installed in the past, the object has been to replace the crucible process by the electric furnace, to make special steels electrically. At South Chicago and at Worcester the Héroult furnace enters into a wider field, as the steel is intended specially for rails and wire. The manufacture of tubes and other products from electric steel is likely to follow. The Steel Corporation thus becomes the pioneer of electric refining of steel for large tonnage products. The development was clearly foreseen by Dr. Héroult in the paper which he presented at the International Electrical Congress in St. Louis in 1904. This may be mentioned as interesting evidence that Dr. Héroult combines with his eminent qualities as a chemist and engineer a most remarkably sound judgment of industrial evolution. After having pointed out that with the advent of electric steel refining there would be in future no excuse for not making steel free from impurities, such as sulphur and phosphorus, he concluded that he was far from predicting that the electric furnace process would supersede the old metallurgy of steel, "but it will and must cause a revolution, so far as the quality of the metal used in the industries is concerned." This is exactly what now takes place, and the Steel Corporation has become the leader in this peaceful revolution.

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It is to be sincerely hoped that the satisfactory solution of the rail problem, which has become more troublesome from year to

year, will be the first important practical result of this development. Steel men have in the last years inclined to favor strongly the open-hearth as against the converter, and more than once it has been prophesied that the converter was doomed. The combination of the Bessemer converter with the Héroult electric furnace as it will be carried out at South Chicago for rail making, changes the situation completely. Far from becoming a competitor or enemy to the old metallurgy of steel, the electric steel-refining furnace really seems to be destined to give the converter a new lease of life. By the combination of Bessemer converter and electric furnace it is possible to make steel superior in quality to open-hearth, and it is even a possibility that under certain conditions it may be found cheaper. The developments of the future will decide this question. The combination of the electric furnace with the open-hearth at Worcester is not less interesting. The result will be again a decided improvement in the quality of metal. The electric furnace permits the production of a thoroughly deoxidized metal, free from slag and other impurities, with the impurities as low as desired, say phosphorus below 0.01 and sulphur below 0.01 and there can be no doubt that having adopted electric refining the United States Steel Corporation will make the widest and best use of its possibilities.

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What is really at the bottom of the technical possibilities of the electric furnace? Two things are of chief importance. First, the reducing atmosphere, in thorough contradistinction to ordinary metallurgical practice, where heat production is accompanied by oxidation as in the open-hearth with oxygen as active element. The reducing atmosphere of the electric furnace makes it possible to thoroughly deoxidize the metal. The second point of importance is the old well-known feature of electric furnaces—the possibility of producing higher temperatures than can be obtained in ordinary metallurgical furnaces. This is the chief reason of the possibility to thoroughly desulphurize the metal. The higher temperature permits the use of a more basic slag, and, therefore, a much better desulphurization by the same reaction by which sulphur is removed in the basic open-hearth process. But this is not all. Careful investigations of the process by which sulphur is removed from steel in the electric furnace point to the fact that we have here to do with new chemical reactions which are impossible at the lower temperatures of ordinary metallurgical furnaces. The sulphur is removed in the Héroult furnace in form of calcium sulphide, and the formation of calcium carbide appears to play a part in this reaction—a fact which directly indicates the absolute necessity of a very high temperature. The paper by Dr. Amberg, published in this issue, is interesting in this connection.

#### Alloys.

Mr. David H. Browne, who in the past has been deeply concerned in the separation of nickel and copper from copper-nickel matte, contributes to our present issue an interesting concise statement of the remarkable properties of Monel metal, a nickel-copper alloy about which much has been heard during the past few years. That it should be possible to prepare from nickel and copper an alloy with about 25 per cent greater tensile strength and 50 per cent greater elastic limit than the best rolled steel, with the additional quality of incorrodibility, is

something as remarkable and unexpected as was Heusler's discovery that it is possible to make magnetic alloys from unmagnetic metals. But these two discoveries must have a decidedly stimulating and encouraging effect, as they show the unlimited possibilities of experimental researches on alloys.

#### "The Old Order Passeth."

For many years the visitor to the "Argo" plant of the Boston & Colorado Smelting Co. was shown courteously the original Brown straight-line roasting furnace, the Pearce turret roaster, the large reverberatory copper furnaces, and the intricacies of the Ziervogel process. But he was denied admission to the gold refinery, where the gold was separated from the copper and refined by furnace methods. Lately, the refinery was burned down, and as the electrolytic refining of copper has developed into a much more efficient process for the separation of gold and silver from copper than the Pearce process, the Argo refinery will probably never be rebuilt. As the reason for secrecy no longer exists, Prof. Pearce's son, Mr. Harold Pearce, has presented a paper describing his father's process at the New Haven meeting of the American Institute of Mining Engineers. It is in the nature of an obituary of a metallurgical process which has lived a long life of usefulness.

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It was generally apprehended by practical smelting men that two general reactions were used. The first was presumed to be the formation of the copper bottoms out of copper matte as it was well known that metallic copper so formed will concentrate with it nearly all the gold. The second reaction was guessed by Mr. H. W. Hixon to be the smelting of these copper bottoms with pyritic ore and in Chapter II of his "Notes on Lead and Copper Smelting" he describes this reaction. The Pearce process now proves to be exactly what Mr. Hixon had conjectured, though, of course, modifications were made in its practical working. The Pearce gold process, briefly described, consisted of the formation of "copper bottoms" containing 100 oz. to 200 oz. of gold, while the matte formed with it contains only one-fifth of an ounce of gold—a sharp separation. This metal is granulated and melted with iron pyrites in a reverberatory furnace. Another "copper bottom" is made concentrating the gold further. The operation depends on the fact that the solubility of gold in metallic copper is far greater than its solubility in copper matte. Three "granulations" and "strippings" with pyrites were made, till finally a rich alloy containing 10 to 20 per cent gold was made. This was sent to the refinery where the same operation was repeated two or three times, but in crucibles, instead of in a reverberatory furnace. Finally gold bullion, 920 fine, was produced, which could be sold to the United States Mint. The recovery of gold varied, but was as low as 98 per cent and as high as 100 per cent. Epitomized the process depended on the "distribution coefficient" of the relative solubilities of gold in metallic copper and copper-iron sulphide and the ability to successively increase the mass of copper-iron sulphide by the addition of iron bisulphide.

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One of the advantages of the process was that it required only simple and cheap apparatus. It was designed for the neces-

sity which presented itself of treating cheaply copper ores rich in the precious metals and the "Argo" smelting plant eventually became more of a gold plant than a copper plant. The fact that no expensive apparatus was needed reminds us of that very efficient process for separating copper-nickel matte by smelting with salt-cake. This process depends on the difference of the solubility of two substances in one solvent (whereas the Pearce process depends on the difference of the solubility of one solute in two solvents) and is commercially efficient because of simple form of treatment. The Pearce gold process produced nearly 1,600,000 oz. of gold in the 30 years of its existence. It had a profound influence on the mining of ores in Colorado, as it gave a market for ores which were hard to treat otherwise. Its history reflects great credit on its inventor, Prof. Richard Pearce, who is a Nestor of the metallurgical profession. It is no disgrace, either, for it to retire from the field in favor of the electrolytic copper refining process.

#### A Practical Point on the Use of Pyrometers.

Compared with the simple mercury thermometer, electric pyrometers, whether of the resistance or of the thermo-electric type, have the disadvantage of not being a self-contained unit. They consist of three distinct parts: at one end, where the temperature is to be determined, we have the resistance wire or the thermocouple; at the other end, where the reading or the record is taken, we have the indicator or recorder; and as connection between both ends we have the connecting wires. Manufacturers of pyrometers are now able to make the bulbs containing the resistance wire or the thermo-element, as well as the indicating and recording instruments, fully reliable under the difficult conditions which prevail in the workshops. But the fact that there must be connecting wires constitutes a certain inherent weakness from a practical standpoint in more than one respect. A peculiar mistake which users of thermo-electric pyrometers are liable to make and which, as a matter of fact, is made more often than would seem probable, is discussed in an article by Mr. Wilson in our present issue. The mistake is the connection of the thermocouple of a high-resistance pyrometer with the indicator of a low-resistance pyrometer. Why this is wrong Mr. Wilson shows very clearly. How such mistakes can happen is also clear. Buyers of a platinum thermocouple get a certificate from the Bureau of Standards giving the relation between temperature and millivolts. Then they find in the catalog of an electric instrument maker a millivoltmeter that takes their fancy, and they order it without stating for what purpose and without thinking whether it will suit their thermocouple. Mr. Wilson's article deserves the fullest attention of users of thermocouples. It will be seen that there is absolutely no mystery in this matter. To make such a mistake as mentioned above is about of the same order of engineering thoughtfulness as to connect an alternating-current induction motor to a direct-current network or to couple a narrow-gauge engine with a standard-gauge car, trying to run both on two rails.

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A second point of weakness due to the connecting wires was emphasized by Dr. Northrup in his recent paper before the American Institute of Chemical Engineers and published in our February issue. It is that people are only too liable to be

simply careless in making the wire connections. As Dr. Northrup pointed out, if a mechanical engineer wishes to transmit 10 hp across a factory, he puts up in a substantial manner a line of shafting and it stays in order. An electrical engineer could carry the same power across the factory with a single wire the diameter of a pin, laid on the floor. This is a serious source of temptation to put up flimsy, uncertain wiring. If something goes wrong, as it surely will, it is then easy to kick that electrical installations cannot be relied upon like mechanical installations. If the 10 hp were carried in a lead-encased cable, as substantially supported as the shafting, the electrical transmission would remain in operation when a line of shafting and belts had rusted and rotted into uselessness.

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At first glance it might seem that the optical pyrometer and the radiation pyrometer are free from this source of weakness, as the measurement is here made from a distance. But in reality the radiation pyrometer employs a thermocouple on which the heat rays are concentrated so that the radiation pyrometer is really an elaboration of the thermo-electric pyrometer. On the other hand, in the optical pyrometer we have a luminous source which must be kept constant, but which is liable to change by the battery running down or the filament changing its efficiency. Further, the lenses and prisms must be kept clean; they play a rôle somewhat analogous to the connecting leads in an electric pyrometer. These remarks are not made to discourage in the slightest degree the use of pyrometers. Fortunately, people can no longer be discouraged now. The danger is now at the other extreme. People expect too much from pyrometers. The way in which sometimes men are handling pyrometers makes it absolutely necessary to emphasize again and again that at least ordinary care and thoughtfulness are required in pyrometer installations. In spite of all progress that has been made in making pyrometers more reliable, stronger and better adapted to workshop conditions, yet absolutely foolproof they cannot be made.

#### The Reduction in the Price of Steel.

The reduction in prices of steel products which has been in progress since the decision of Feb. 18 to abandon the policy of maintaining former prices is likely in the long run to restore the industry to its former activity. It was not an easy task which a few men set for themselves towards the close of 1907, when it became evident that without intelligent direction the steel trade was likely to find itself in a worse panic than ever before in its history. The industry was subject to great dangers. Not only had capacity grown at an enormous rate, but there was a large amount of capacity just installed which was not really needed, and there was still more capacity on the way. The capacity was becoming unwieldy, even though no financial panic or industrial depression had intervened. In a period of three years of unexampled activity, when the problems of the trade were largely those of avoiding undue delay in the filling of orders, the usual spirit of moderation and conservatism had been lulled, and with the suddenly arising insufficiency of orders, complete demoralization threatened the industry. The industry was saved from demoralization through a campaign of education in co-operation and conservatism. On the surface it was a campaign to maintain prices, but it was



totally distinct in its methods from other operations in the past which have had similar ends in view, and instead of merely exercising a restraint which would leave sellers more prone than ever to cut prices when the restraint was removed, it inculcated motives and principles the influence of which has remained and has produced a moderation and conservatism in the readjustment of prices, now that the market has officially been declared "open," which has surprised even the more ardent supporters of the campaign.

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The lower prices were necessary, and it is well at this time to consider the position which the iron trade found itself in at the time of the panic of October, 1907. The need for restraint did not arise merely from that panic; the trade had troubles of its own, through the remarkable and not altogether well-timed burst of activity in new erection. Let us go back of that panic. In our issue of March, 1907, our report on the iron and steel market pointed out, in tabular form, by half years, the increases in pig iron capacity which had been and were being brought about through the completion of new furnaces. This showed that while in 1902 "it taxed the resources of the industry to make 17,821,307 gross tons of pig iron, in 1906 25,307,191 tons had been made, and the prospects in March, 1907, were that 28,000,000 tons could be made in that year," and the report then remarked: "With the present trade outlook it is certain that no such tonnage can be absorbed." Those words were proved true, and they would have been true had there been no panic in October. It is true the industry did not stop its increasing production until the panic, for in the panic month of October it made more pig iron than in any previous month in its history. Nevertheless, the year's production was only 25,781,361 tons. With a few additional furnaces projected, the position to-day is that, with present new erection completed, the industry will have an annual producing capacity of not less than 32,500,000 tons. Our report in March, 1907, referred to the probability of a reaction in pig iron prices within a few months, but said: "It does not follow that a reaction in prices of finished steel products is probable, for the double reason that pig iron has reached a level out of all proportion with finished products, and prices of finished steel products are closely held. They were prevented from unduly advancing, and can within limits be prevented from declining." How closely finished steel prices were held, and how wide were the limits within which they could be kept from declining, market history since then has plainly shown.

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With this enormous capacity in prospect, 32,500,000 tons of pig iron and commensurate capacity in steel making and rolling, when the greatest calendar year's pig iron production has been 25,781,361 tons, it is evident that in order to permit competition with wood and concrete, and for the encouragement of new uses and wider employment, a reduction in selling prices was clearly dictated. Had capacity not been swelled far beyond the requirements even of the high-pressure period which culminated in 1907, a revision would doubtless have been necessary, but with the added load the necessity was made the more imperative. The reductions in prices are by no means a dead loss. There are compensations which may make up all the

loss, and more, too. In the first place, a reduction in wage rates, where they were unduly advanced through the abnormal high pressure conditions in the recent active period, is regarded as certain within the near future. Then other economies will be introduced with more energy as the necessity has been made more apparent, while with increased tonnage operating costs should be reduced very materially. In some respects the steel trade was less well prepared than ever before for a period of slack operation, due to its having on its hands large mills built only for tonnage, and taking the place of what under former practice would have been groups of smaller mills, some of which could have been operated and others closed. Then the large continuous mills have involved heavy charges for roll changes, when specifications were of the mixed character prevailing last year. That larger tonnages will come in the measurably near future is not to be doubted, and it may be sooner than is now generally expected that full employment will be given the industry, even though it has a capacity fully a fourth larger than has ever been engaged in a calendar year.

### Socialism and Social Efficiency.

It is perfectly true that on but few subjects is there any uniformity of opinion. And this heterogeneity is the spice of life. But of all complex subjects, to our mind, the relation of capital and labor is the most complex. Let the fact be granted that intelligently directed intelligent labor is the prime essential of success in manufacturing. Then it can be deduced that for the maximum of commercial efficiency the laborer should have reasonable hope, comfort, and a chance for the pursuit of happiness. Such ideal conditions rarely exist, and the complaint of their absence takes the form of discussions, pro and con, of the vast mass of vague doctrine that is circumscribed in literary fashion by the word "Socialism." Of the mass of seething literature that comes from the welter of arguments on this subject, the writings of two men, one brilliant yet visionary, the other cold, hard-headed, but warped in his views, have appeared. The protagonist of the socialists is Mr. H. G. Wells, who has mixed some common sense with his visions. The champion of the anti-socialists is Mr. W. H. Mallock, whose "Critical Examination of Socialism" is hailed with joy by the followers of the old English school of *laissez faire* economists. Both of these men cover a wide range of literary activity, for each is a philosopher, essayist and novelist, as well as a student of social evolution. Each attacks the subject according to his own bias. Wells minimizes the strength of modern society. Mallock minimizes the weakness of the reform impulse. To our mind, the truth lies between the extreme positions.

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Socialism is essentially a philosophy of discontent. Ninety-nine per cent of the socialists in America have some real or fancied grievance against society. The remaining 1 per cent have a lively and quick sympathy that extends their altruism so that it absorbs in the ego of the individual the woes of all the unfortunate. Things are queer and lopsided with man and there is a concentration of money-making and happiness-making abilities in the minority. This has always been so, but the flux of modern social and industrial evolution has aggra-



vated this lack of balance. Distribution of money and happiness is always unequal, and sometimes unjust. In modern times, the efficient man has become much more efficient and his coefficient of efficiency is multiplied by a vastly larger quantity, due to the fact that the industrial machine as well as industrial machinery has an immensely larger output. The growth of science has changed our way of looking at the world. The growth of applied science has changed our world. The modern business man is simply a glorified money-getting brain, and a brain that absorbs other brains, as the germ cell absorbs other inferior cells. Now, we believe that the doctrine of Gen. Francis A. Walker, who, let it be remembered, was the pioneer in technological education, and, to our minds, thus fittingly a political economist, is sound. In modern society the margin of superiority of one enterprise over another similarly located, depends on the entrepreneur whose intelligence directs the business. Assume three factories precisely the same as regards machinery, labor and location, each employing 100 men, and the first making a profit of \$100 per year per man, and the second a profit of \$200 per year per man, and the third has no margin after proper charges for interest, depreciation and insurance against business risks are deducted. The entrepreneur or owner-manager of the first makes \$10,000 per year as his margin over the third factory, which, inefficiently managed, has no margin, while the manager of the second plant has a margin of \$20,000 over the poorest plant. This is a bald and concrete statement of the simple facts.

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Now, we will assume that the number of employees is not 100, but 10,000. Then No. 2's differential advantage, assuming that his mind and capacity is of such a character as to permit of expansion, which is only an approximation to the truth, is \$2,000,000 per year. These cold figures are, with proper corrections, the ideal expression of the reason why the modern captain of industry reaps profits out of all proportion to his father's profits. It is simply the logic of political economy. The discontented man may say no man should earn over \$10,000 per year and this is a question of social ethics and not of political economy. With no small measure of truth the advocate of socialism affirms that success—the magic word of America—comes, not to the worthy planner and doer of big things, but to the shrewd and calculating financier who studies trade conditions and the sinister motives of humanity; in short, that "in business it is not the survival of the fittest, but the survival of the slickest." The alliterative aphorism is only too true in many cases.

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It is a fact that the trust when well operated is the most efficient instrument of production that the world has ever seen. The cost of production has been reduced, but the cost of retailing, or cost of secondary distribution, is exceedingly high and the means are inefficient. A small consumer buys in a small town in New York State from a hardware store 10 lb. of eight-penny wire nails for 50 cents. For this he pays 15 cents to the producer of steel for digging the ore out of the ground, mining and coking the coal, transporting ore, coke and limestone to the blast furnace, turning these into pig iron and slag, and making steel billets out of the pig iron. Certainly this is a very low figure considering all these laborious proc-

esses. Then he pays  $4\frac{1}{2}$  cents for the conversion of the steel into wire and from wire into nails and packing the nails into a keg. He pays the railroad 2 cents for transporting these nails to the place of consumption, finally he pays the retailer, assuming that the latter buys a carload, 28.5 cents for the privilege of going into his store and having the nails weighed out and wrapped up in a paper by a clerk with a pleasant smile, which smile he does not always get. Somehow or other, in spite of the great value to the nation of the body of retail merchants, the charge for retailing does not seem commensurate with the value of the service. On the other hand, the price of the producer is perfectly fair when regard is paid to the amount of labor and pains it has taken to make the nails. Summarizing the conclusions, let us say that the trust has solved the question of cheap production, but the future problem is cheap and efficient distribution.

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With regard to government operation of the public utilities socialism does not seem to promise much. Ninety per cent of the privately owned plants give efficient service to the consumer, while 90 per cent of the municipal plants give inefficient service. This is the judgment of a well-known public accountant. Managing and technical ability are not paid adequately, and, when not paid adequately, their work is not good. Hence, the consumer suffers in increased taxes or in poor service. For it is an axiom of political economy that the consumer in the last analysis pays the bill. Furthermore, as in any new development, such as a new smelting process, it is always well to see how the new proposal works on a small, practical scale. Many socialistic or communistic bodies have been formed, but all, measured by the standpoint of results, are miserable failures. Socialism even as modified by its latest and saner advocates and not as exemplified by the earliest advocates, whose methods were destructive rather than synthetic, takes little account of human weakness and human selfishness. Social reform will take quite a different course from the sweeping changes that the socialists demand. The problem of distribution can be solved by co-operative stores, intelligently managed. The partial amelioration of the working classes can be attained by cheap, fireproof, sanitary dwelling houses. Their modest happiness on the one day of leisure can be made at least possible by the revocation of ridiculous blue laws. The cost of living can be reduced by intensive cultivation of small family gardens by each working family. A graduated income and inheritance tax will give funds in the future, not so much, we hope, for mammoth battleships as for technical and trade schools. Better distribution of financial knowledge will improve the position of the small investor and extend his number and conserve his savings. As medical science more and more seems to rely on the powers of the human body to resist disease when nature is not restricted, so political science must turn to perfectly natural means for building up the political body, to trust in plain common-sense science rather than to the nostrums of the quack. Men and women separately and individually must learn the efficient way to live as well as the efficient way to make a living. The health of the political body depends on the health of its individual cells. Socialism complains that society is sick. But social reform brings the invalid back to health.

### New York City Proposed for the 1912 International Congress of Applied Chemistry.

In the past Paris, Berlin, Vienna, and Rome have enjoyed the privilege of entertaining the International Congress of Applied Chemistry. This spring it will meet in London. It is now proposed to issue an invitation to the London Congress to hold the next meeting, in the spring of 1912, in New York City.

A preliminary informal discussion had taken place on this project some time ago at the invitation of Dr. Chas. Baskerville. The first open meeting, called by the temporary committee for discussion of the project was held at the Chemists' Club, New York City, on February 20, Dr. Wm. H. Nichols being chairman and Dr. H. Schweitzer acting as secretary.

A motion of Dr. Bogert was carried, to the effect that it was the sense of the meeting that preparations should be made to issue the invitations. A general meeting of representatives of societies, universities and manufacturers will be called for April 3.

A committee was appointed to go to Washington to request Congress to give the required authority to the Secretary of State to issue the official invitation.

### Niagara Falls Meeting American Electrochemical Society.

Very great interest is already manifested in the coming annual meeting of the American Electrochemical Society, to be held at Niagara Falls on May 6, 7 and 8.

Dr. E. G. Acheson, as president of the society, is endeavoring, together with all the Niagara Falls members, to make this convention a truly memorable one in every respect.

The society has grown wonderfully during the past year and the membership is about to pass the 1000 mark.

The whole first day of the convention is to be devoted to the electrometallurgy of iron and steel, and Messrs. FitzGerald and Bennie are endeavoring to arrange a most interesting program representative of the new industry. Papers are expected on all the important processes in this field. A paper on the Héroult steel process is expected from Mr. Robert Turnbull, Dr. Héroult's chief engineer. Dr. Girod has cabled from France that he will send a paper. So will Dr. Kjellin of Sweden and Mr. Gin of France. Papers are also expected from Mr. Stassano, Mr. Keller and others. Dr. Haanel has been invited to present a paper.

Aside from the preparations which are being made for the professional sessions, the social side is not being neglected. The "irrepressible Section Q" plans some marvelous entertainments, and headquarters will be at the Clifton Hotel, on the Canadian side.

### The Héroult Furnace Adopted by the United States Steel Corporation.

The United States Steel Corporation has adopted the Héroult electric furnace and steel process. During the last two years an investigation of electric steel furnaces was made abroad by engineers of the Steel Corporation, and on the favorable reports received from these engineers and from the patent attorneys and experts, the board has now decided to appropriate the necessary funds at once.

For the present two electric Héroult furnaces, each of 15 tons' capacity, are to be installed, one at the South Chicago works of the Illinois Steel Company, and the other at the Washburn & Moen plant at Worcester of the American Steel & Wire Company.

At the South Chicago plant the Héroult furnace will be used for refining liquid steel taken from Bessemer converters to make a high-grade steel rail ("tool-steel rail") and high-grade steel axles and car wheels.

At the Worcester plant the Héroult furnace will be used for

refining liquid steel taken for two 50-ton open-hearth furnaces to make high-grade wires (for instance, low-carbon telegraph wires) and other high-grade specialties.

Concerning the daily output of the 15-ton Héroult furnaces the estimates vary somewhat. *Iron Age* estimates an output of about 500 tons per 24 hours, but this seems high and is probably a misprint. If on the experience with former electric furnaces the complete time required for finishing one charge is taken as one hour, or an hour and a quarter (which is quite a conservative estimate), then the output of a 15-ton furnace in 24 hours is about 300 to 350 tons.

It is probable that another Héroult furnace of the same size will be installed at Homestead. It is contemplated to follow this up with the erection of 30-ton and probably even larger furnaces later on.

The construction of the furnaces at South Chicago and at Worcester will be vigorously pushed and both plants are expected to be running in about three months.

We comment on this development on page 99.

### E. G. Acheson, D.Sc.

The University of Pittsburgh conferred on Mr. Edward G. Acheson, president of the International Acheson Graphite Company of Niagara Falls, N. Y., the degree of Doctor of Science on Friday, Feb. 12. The convocation was held in Carnegie Music Hall and was in commemoration of the birth of Abraham Lincoln and Charles Darwin. It was made memorable by the presence of Hon. James Schoolcraft Sherman, vice-president-elect. The degree of Doctor of Science was conferred upon Mr. Acheson in recognition of the fact that the many industrial and engineering successes he has scored are the results of his scientific research.

It is hardly necessary to refer here to Mr. Acheson's pre-eminence in electric furnace work and to the fact that Acheson graphite is used all the world over by electrochemical engineers. But Mr. Acheson's influence extends much beyond the purely electrochemical field and is felt in many industries. His work has added very materially to the world's wealth and will be of material assistance in the future conservation of our natural resources. This is particularly the case with lubricating oils, as his latest invention of "deflocculated graphite" and applying it to lubrication is esteemed and appreciated as a factor destined to largely conserve the world's supply of lubricants.

In many respects Mr. Acheson's work has been marvelous, for his success in making valuable new articles from commonplace raw materials has opened new possibilities in many fields, and by conferring on him the degree of D.Sc., the University of Pittsburgh has given honor where honor is due.

### The Iron and Steel Market.

At a meeting of prominent officials of the United States Steel Corporation and most of the important outside steel producers, held in New York on the afternoon of Feb. 18, it was decided to declare an open market on all steel products with the exception of standard rails, each producer to find his own price.

This action was taken for several reasons. Immediately following the panic of October, 1907, an arrangement was made between the principal producers whereby they would interchange information freely and avoid naming new prices for their products. The object was to maintain profits, avoid demoralization in the market, protect jobbers and consumers as to the stocks they had on hand, and protect producers as to the large contracts they had on their books, prices upon which would have to be adjusted in case the open market declined.

In January moderate reductions were made in sheets and tin plates and early in June moderate reductions were made in other products, with the exception of standard rails. The immediate objects of this operation were accomplished, stocks



and contracts being protected. Another object, that of avoiding demoralization, was also accomplished, in a measure, even should the market be declared open, because during the period of 15 months in which conferences were held a feeling of confidence and desire for co-operation was developed and established, the effect of which bid fair to remain even should the market be declared open.

One object very distinctly failed of attainment, that of stimulating business and restoring the trade to its former tonnage basis. There was a more or less regular improvement in demand in 1908, particularly in the second half of the year, but in the new year the movement was in the opposite direction. It became increasingly certain that lower prices would have to be made, partly because some producers were cutting the established prices, but chiefly because it required a distinct incentive to bring out better orders.

The declaration of an "open market" was, of course, largely a matter of form. The majority of manufacturers wished to reduce prices, but did not wish to reduce them indefinitely, desiring to stop at the highest practicable point, and the notice given that reductions would be promptly met was expected to act as a brake and prevent the reductions proceeding too far.

The outcome has fully justified the expectations, while many have been surprised at the moderation displayed. One circumstance which contributed much to the orderliness of the readjustment was the fact that no large orders were pending. There was no incentive to name particularly low prices in order to secure special orders, and besides this the spirit of co-operation instilled in the past 15 months remained, whereby individual producers expect only to receive their share of the tonnage and do not wish to book a part of the proportion at an especially low price.

Within a couple of days after the market was declared open a stable level was found for plates, shapes and merchant steel bars, plates and shapes being at 1.30 cents a pound and steel bars at 1.20 cents a pound. The previous official prices had been 1.60 cents on plates and shapes and 1.40 cents on steel bars, the prices prior to the reductions of June, 1908, being 1.70 cents on plates and shapes and 1.60 cents on steel bars. A considerable portion of the total tonnage had been selling at less than the official prices, narrow plates being sold at 1.40 cents to 1.50 cents and shapes in some cases down to 1.25 cents, so that while the nominal reduction was \$6 a net ton the actual reduction only averaged \$4 or \$5 a net ton. In bars, the 1.40-cent price had been subject to the regular concession of \$1 a ton to large jobbers and some large manufacturers, while the new price of 1.20 cents is net to all interests, so that the bar reduction is \$3 to \$4 a ton.

The National Tube Company, Feb. 22, announced to its trade a reduction of five points in the official list, making the official discount 80 per cent off, in "jobbers' carloads." The actual prices are regularly an extra half-point and 5 per cent to large consumers and an extra point and 5 per cent to large jobbers, making the new inside prices 80½ and 5 and 81 and 5 off list. As the list averages about 10 cents a pound, a point is about \$2 a net ton, and the total reduction is about \$10 a net ton. Pipe prices had not been shaded, so that the actual market has declined by this amount. The prices had been particularly high, and the new price is no lower than prevailed from October, 1905, to October, 1906, a period of general prosperity. Through a succession of advances pipe had reached a point quite out of relation with other finished steel products.

The American Sheet & Tin Plate Company did not announce new prices on sheets and tin plates, preferring to see whether developments in the crude steel market would require reductions. The American Steel & Wire Company announced Feb. 23 that it would issue a new list on March 1, to which basis all shipments made Feb. 19 and later would be adjusted.

#### Pig Iron.

The pig-iron market has shown relatively little weakening tendency on account of the developments in the steel trade,

although business, already very slow, was practically suspended. The tendency in pig iron would be to advance, in anticipation of the larger tonnage of business the reductions in steel prices tend to bring out ultimately, were it not for the fact that a reduction in ore prices is regarded by the trade, whether rightly or wrongly, as a distinct probability. The pig-iron market, as to the existing prices of raw materials, coke and ore, was thoroughly liquidated last October. While there was a rather sharp advance thereafter, about half the advance had been lost up to the time of the readjustment in steel prices, while there was an unduly large spread between pig iron and steel. Barring a possible reduction in ore, pig iron should advance rather than decline, but as it is some time may elapse before a trading basis is found satisfactory to both parties. Meanwhile the market in the central West can be quoted tentatively at \$15 for foundry or basic and \$15.50 for Bessemer, f.o.b. valley furnace; 90 cents higher delivered Pittsburgh.

#### Steel.

The billet, sheet bar and wire rod market has been slow in developing, chiefly on account of the system of basing prices on a Pittsburgh rate, plus freight to point of delivery not working out as satisfactorily in crude steel as it has in finished steel products. Practically all finished steel products, with the exception of rails, are customarily based on a Pittsburgh price plus rail freight to point of delivery. This was the rule with billets and sheet bars until about a year ago, when, on account of the shading of mills at a distance from Pittsburgh, a system was established of charging only half the freight advance from Pittsburgh, when the rate was from \$1 to \$3 a ton. This, with billets at \$25, Pittsburgh, made the regular price \$26.20, Philadelphia, the freight being \$2.40, and \$26.50, Chicago, the freight being \$3. Even with these allowances it has been possible for months to shade the Philadelphia and Chicago prices, on attractive business, through the concessions of nearby steel works.

#### The High-Speed Tool-Steel Patent Decision.

The famous patent suit of the Bethlehem Steel Company against the Niles-Bement-Pond Company for infringement of two fundamental patents of F. W. Taylor and M. White (668,369 and 668,270, both of Feb. 19, 1907,) has been decided in favor of the defendant, and the two Taylor-White patents in question have been found invalid by the Circuit Court of the United States for the District of New Jersey. Mr. Thomas W. Bakewell and Mr. Francis T. Chambers represented the complainant. Messrs. Duell, Warfield and Duell represented the defendant. The decision was written by District Judge Cross. We have prepared from the decision the following abstract:

"It is obvious that the question of the validity or non-validity of these patents is highly important, not only to the complainant and defendant, but to all workers in the art, since they apply to substantially all steels for cutting tools in the composition of which chromium and tungsten or molybdenum appear, and to all temperatures applied in treating such steel for such purposes in excess of 1725° Fahr. If the patents are sustained, any considerable progress in the art will manifestly be impossible during the period of monopoly thereby granted. This is not stated as a reason why they should not be sustained, if they properly may be, but rather to indicate the serious nature and importance of any conclusion that may be reached."

As to the character of the invention under dispute, reference is made to the first Taylor-White patent specification, where it is alleged that formerly (i. e., before 1900) the maximum temperature considered permissible for heating steel was from 1500° to 1550° Fahr. Taylor and White then continue: "Our invention is based on our discovery that while it is true that tools made of air-hardening steels all rapidly deteriorate at temperatures in excess of a bright cherry red (though it must be understood not all at the same temperature), it is also true that when air-hardening steels are made with certain constitu-



ents in ascertained proportions this deterioration only prevails during a limited range of temperature above the bright cherry red—that is to say, from about 1550° to 1700° Fahr. (corresponding to a light salmon color)—and on further discovery that above this range of temperatures, which we call the 'breaking-down point,' and from 1725° Fahr. up to a temperature at which the steel softens or crumbles when touched with a rod (approximately 1900° to 2000° Fahr.), the efficiency of tools of such special steels—that is to say, their cutting speed and also their uniformity in efficiency—is greatly increased and largely so in proportion to the degree of heat to which they are raised. This is so much the case that their cutting speed may be stated to be from one and one-half to two and a half times that of the tool heated, as heretofore, to temperatures below the breaking-down point."

The decision of the court emphasizes that there is no new composition of steel invented by Taylor and White. According to the testimony of Mr. White himself, there is no such thing as Taylor-White steel, but their patent simply claims a process for the treatment of a steel of certain limited compositions.

In the first patent their heat treatment is applied "by one set of claims to steels containing not less than ½ per cent chromium and 1 per cent tungsten, and by another set to steels containing 1 per cent of chromium and 4 per cent tungsten, and by all of the claims of the second patent to an air-hardening tool-steel containing not less than 3 per cent chromium and not less than 6 per cent of tungsten. All of the claims, therefore, specify tool-steels containing certain percentages of chromium and tungsten, but they are clearly not limited to the percentages thus specified." \* \* \* "This gives to the claim an extremely broad scope. The method of the patents is applied to almost every possible percentage of the chrome-tungsten composition of steel."

The decision of the court lays great stress on the alleged "breaking-down point" between 1550° and 1725°, mentioned in the patent. "If such breaking-down point did not exist, or did not exist between the degrees of temperature named, the patentees made no discovery and no invention; or, again, if workers in the art were accustomed to temper their steel by the application of more or less heat, according to its composition, and in its treatment applied temperatures exceeding 1725°, the higher limit of the alleged breaking-down point, the patent must likewise fail.

"In the consideration of these questions, which to some extent overlap each other, it would seem that the prior art need not, and ought not, to be strictly limited to what was done in making metal-cutting tools of the precise character indicated in the patent. The questions involved, broadly considered, have to do with the tempering of steel, the use to which the steel might subsequently be put being relatively unimportant." \* \* \*

"A reasonable application of this principle would seem to broaden the prior art, for if it were customary to temper steel in analogous arts by the application of very high temperatures, equaling and even exceeding those of the patents, and this without injury then the application of the same treatment, for a like purpose, to steels for metal-cutting tools would not necessarily involve invention."

Great stress is laid on the fact that there is no general rule as to the temperature to which steel is to be heated. Mr. John Fritz is quoted as saying that the temperature the steel will stand depends on its composition and that "if you know the composition of the steel you can generally tell pretty near what to do with it."

From Dr. Hennig's testimony reference is made to the fact that "the Mushets in their circular and instructions for treating their steel specified a yellow heat for hardening, which temperature, by all authorities given, was over 2000° Fahr."

Prof. J. O. Arnold's testimony is then quoted, based upon "the experience of all high-speed steel makers," and upon certain specific experiments of his own, that there does not exist

a "breaking-down point" between 1500° and 1750° Fahr., as claimed in the Taylor-White patent.

Reference is then made to "certain tests made at the complainant's works during the progress of this suit, in the presence of some of the counsel and experts of both parties." The object was "to repeat in open tests what had been done in a so-called secret trial and clearly show the existence of a breaking-down range for chrome-tungsten tools, and the inevitable response of chrome-tungsten steels to the treatment of the Taylor-White process, so called." The result of the open test was to show "that a heat of 1500°, regarded by the patent as the highest point of efficiency in the prior art, was, indeed, the lowest point of efficiency; that from 1550° to 1600° the same degree of efficiency, or rather of inefficiency, was substantially maintained; and that from and after a temperature of about 1600°, and not of 1725°, as called for by the patent, marked improvement was shown. In short, every material assertion of the patent bearing upon the point in question was disproved. In the presence of open tests, the private tests of either party must, to some extent give way, because they are relatively unsatisfactory; that is to say, ex-parte tests will almost invariably be found to support the theory of the party making them." \* \* \*

"If then we accept these open tests at their face value, we would have this startling result, if the statement of the patent as to the prior art be accepted, that it was therein the custom, instead of heating a tool to the temperature which would impart to it its greatest efficiency, to heat it to a point which gave it its least efficiency, and this, notwithstanding the fact that from the earliest times all workers in steels, from the village blacksmith up, were accustomed by the use of a file and by other means to ascertain when a tool had attained its greatest efficiency.

"The testimony shows that it would have been impossible to make an efficient cutting tool out of the chrome-tungsten steel in vogue for some years prior to the patent in suit at a temperature below those within the patent in suit. Such steels not only required, but, in fact, were given, a much higher temperature than that given to the old carbon and cast steel, and a much higher heat treatment than 1725° named in the patent as the highest of the temperature defining the breaking-down point. The art developed continuously along this line as the carbon constituent was reduced and the toughening elements were introduced into the composition of steel.

"No satisfactory basis appears in the record for the assertion that the patents in suit led up to or were the means of producing or introducing the high-speed steels. On the contrary, such steels were developed normally along lines laid down and recognized prior to these patents. The process of their development has always been gradual, but at the same time consistent and in a single direction, and may well be characterized as one of degree, and the same may be said of their treatment.

"If the composition of steel were always uniform, the best heat treatment for that particular kind of steel, once ascertained, could safely be followed. But inasmuch as the compositions of steel are not uniform, but variable, and frequently unknown, it has always been more or less a matter of experiment to ascertain the degree of heat requisite for their proper treatment, and it is this experimental practice to ascertain what after all was merely a matter of degree that precludes all possibility of invention in the patents."

This ascertaining the proper temperature by experiment is pointed out in the testimony to have been Mr. John Fritz's method, while he was in the steel business up to 1894. "In view of what he says it must necessarily be inferred that if any of the steels of later composition had come into use in his day, he would have had no difficulty in ascertaining by experiment, as he had done with Mushet and other steels, the best method of treating them; it cannot be supposed for a moment that if he had found a steel which did not properly harden at 1550° that he would have been completely baffled and would have abandoned its use; on the contrary, his own testimony

shows he would have experimented with it, and heated it until it did respond, and properly, to the treatment, and in pursuing this course he would have done, as we shall see, no more than other practical men would have done, and uniformly did do in the prior art."

That the same experimental method has been followed by other steel men is concluded from the testimony of several experts. The court found that Taylor and White "substantially pursued" the same method. "In view of these findings it is impossible to see what of novelty and invention there was in what they did. Others were doing and had done the same thing. That they, by means of apparatus, more careful or different treatment, perhaps, and under highly favorable conditions, should have succeeded at one of the best-equipped shops in the country in producing, if they did, somewhat better tools than others produced, is neither invention nor evidence of invention."

Anticipation is found in "the Crescent public use" at the Crescent works of the Crucible Steel Company of America, for more than two years prior to the time when applications for the Taylor-White patents were filed. "The question, and this cannot be too carefully noted, is not whether the Crescent people made as good a tool as the complainant made under the patents, but rather whether, in making similar tools, they pursued substantially the same method."

"No small part of the complainant's testimony has been offered for the purpose of showing the utility of the patents," by offering as testimony articles from various publications. These are regarded as hearsay evidence.

The case is finally summed up as follows: "The prior art was radically different from what the patent would lead us to believe. There was no such thing known to the art as a breaking-down point. On the contrary, it is established that given a new steel, particularly if the composition were unknown, it was customary to experiment with and test and try it and thereby ascertain the best method of treating it; that in pursuing this course, the method of the patent was substantially followed and temperatures as high as any mentioned therein, or higher, were, not in isolated cases, but in ordinary practice, resorted to. Moreover, as a matter of fact, the patentees themselves in making their alleged discovery simply adopted the experimental rule which other workers in the art, both before and since, adopted and used, and if, in the race, the patentees have surpassed others, it has not been through novelty of procedure, but by means of special facilities, apparatus and methods not embraced in the patents.

"These patents in principle are not unlike the one considered and held invalid by the Circuit Court of Appeals for this circuit, in *Brady Brass Company v. Ajax Metal Company*, 160 Fed. 84, which turned upon the existence or non-existence in the prior art of a 'critical point.' The first of the headnotes to that case is as follows:

"A mere difference in the proportions of the constituents of an alloy, however useful the result may be, does not entitle the originator to the monopoly of a patent, where such result was reached gradually by continued experimentation by the patentees and by others, all leading toward the same proportions, and the final product differs from those of the prior art only in degree."

"It is with regret that, before closing, I feel constrained to give expression to the following criticism: The complainant's case, aside from the testimony of its expert witnesses, rests in no small degree upon that of a witness who, in the first instance when called by the defendant, showed a lack of memory and an unwillingness to testify as to matters concerning which it would seem as if he must have had more knowledge than he chose to reveal. However, when this same witness was called by the complainant a marked improvement in his attitude and memory was noticeable and he became a mainstay of its case. The record discloses, as it is undisputed, that not only this witness, but another important one, refused to testify for the

complainant until after it had entered into an agreement with them by which, in consideration of their testimony, if the patents in suit were sustained they were to have licenses thereunder. The testimony of witnesses whose compensation is contingent upon the success of the party in whose behalf they testify, whose contingent compensation is furthermore an interest in the very subject matter of the litigation, who refuse to testify until after such contingent consideration is promised, who thereupon testify pursuant to the arrangement and subsequently demand and accept such contingent compensation, cannot but be impaired. Nor is this all, for the first of the witnesses referred to in the first instance demanded a pecuniary consideration for testifying, which he admits he regarded as prohibitive, while the second threatened to withdraw his testimony because of some delay in the delivery of the license, which he was to receive as compensation. It is not merely that such witnesses are interested, for that does not fully express their status; it is rather the character of their interest and the method of its acquirement; they dickered with the complainant for an interest in the *res* as the condition of their testifying. Their compensation, so far as they knew, was dependent upon the strength of their testimony and they had every inducement to make it effective. Furthermore, when testimony is first bartered for by a complainant in a court of equity under circumstances like the above, and the testimony given pursuant to the bargain is accepted and used, not only its equitable standing, but the strength of its case is likewise impaired, for the suggestion will not down that if some witnesses have testified under such an arrangement and for such a consideration, other witnesses in the case may have done the same thing. If testimony of this character is acceptable upon the equity side of the court, it is not improbable that we shall soon have witnesses testifying in damage cases upon the law side, upon contingent fees of 5 per cent to 10 per cent of the amount of the verdict. Conduct of the character above outlined, if not contrary to public policy, is certainly near the border line."

## CORRESPONDENCE

### American Electrochemical Society Election.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—I have just sent to the secretary of the American Electrochemical Society the following letter:

Although I consider that my friends have done me a great honor in nominating me as one of the candidates for president of the American Electrochemical Society, I feel that I am not entitled to it as much as other candidates and therefore ask to kindly withdraw my name from the ballot.

If my friends judge that I can be useful to the society in some minor office, however humble it may be, I shall try to do what I can and work for the interest of our society; but let me start at the bottom of the ladder and not at the top.

YONKERS, N. Y.

L. H. BAEKELAND.

### Reduction of Iron Ore and Steel Refining in the Electric Furnace.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—In the September issue, 1908, of this journal (Vol. VI, page 353), Mr. Francis A. J. Fitzgerald criticizes several points in my paper, published in the August issue (Vol. VI, page 315). To these criticisms I wish to make the following reply:

In speaking of the "practical solution of a problem," I meant the whole system of technical contrivances by the joint action of which the object of the problem is carried out in practice in a convenient and commercially successful manner. This is the task of the engineer, and from this viewpoint I look at the reduction of ore in an electric furnace.

From the practical solution of the problem to its most general application and introduction there is still a long way;



and to reach this end is beyond the power of the inventor and remains the task of the promoter. I have built electric furnaces, which for a sufficiently long period have been in regular successful operation. *Forgable iron and steel have been produced repeatedly directly from ore in a single operation.* Practice has shown that the process devised by me is not only convenient, but quite economical. Hence, electrothermic reduction of iron is no longer a problem, but is an established fact, and I am ready to prove to Mr. Fitzgerald as well as to anybody who might be interested, the truth of my assertion. I do not talk about laboratory experiments, but will carry out the operation with a furnace of 1000 hp, the biggest ever used in electrothermic metallurgy.

It is true that there does not yet exist a second plant of my system where on a large scale iron ore is directly converted into iron and steel. But that does not matter, nor does it refute my statement that it was I who solved this problem in practice for the first time. Capitalists do not invest their money in any novelty at a first appeal. The greater the sum necessary for the erection of a plant on a proper scale, the longer will they hesitate. The inventor must procure the confidence of the public by his perseverance, leaving to the future the general introduction of his process.

The excellent results which I have obtained in my experiments confirm my conviction as to the perfection of my process; I shall persevere and delay does not frighten me. This is my answer to the first part of Mr. Fitzgerald's letter. I hope I have been plain and have avoided any further false interpretations.

I now pass to the second part, in which Mr. Fitzgerald makes a calculation in order to show that according to the figures, which I give in my article, my process is not practical; first, on account of the 4 kw-hours of energy for every kilogram of steel produced; and secondly, on account of the cost of the energy itself, which is about half of what he believes it ought to be.

I cannot agree with my opponent on these points. The rate of 4 kw-hours is not exact, because naturally furnaces of large size would only be used for the reduction of ore by my process, and in these the consumption of energy is greatly diminished, as is shown by the figures in my former article. I repeat what I wrote about the consumption of energy:

"Further, on examining the figures of the different tables, one has to consider the size of the furnace which influences the consumption of energy; it is clear that a small furnace will consume more power per unit of output than a bigger one. For instance, in the refining of steel in the 200-hp furnaces at the Steel Works Stassano (average 1907) 1.26 kw-hours were consumed per kilogram of steel, while 2.3 kw-hours were required with the furnace of 100 hp."

It may be noticed that the experiments of direct extraction of iron from ore to which I refer, were carried out with a furnace of 200 hp. This was the same furnace which for purifying pig iron and scrap consumed in the average 1260 kw-hours for each ton of output (Table D), while the same work done in the furnace of 1000 hp (Table F) required only about 900-kw hours. It is obvious that when reducing ore in the 1000-hp furnace the consumption of energy will be less in the same proportion and will amount to less than 3-kw hours per kilogram of output. The ore used was rather low in quality, containing only 48 per cent of iron.

On the other hand, having never been in America, I cannot say, with authority, whether, as Mr. Fitzgerald pretends, his cost of the hp-year of energy on the new Continent may be right or wrong, although I have strong doubts about his assertion. All I can assert with certainty is that in Europe, and particularly in my own country, there are plenty of hydro-electric plants, partly existing, partly in course of erection, in which the cost of the hp-year amounts to less than 40 francs (about \$8), all expenses, interest and amortization included, so

that I would be the happiest of inventors if I should see my process introduced in only one-hundredth of these plants before I die.

Having thus shown that Mr. Fitzgerald's figures are open to criticism it might not be necessary for me to reply to his final remarks if some facts did not compel me to say a few words about the "Lash process," described in Vol. V, pages 455 and 456 of *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*.

From this article it really appears as though the inventor of this process believes to have come quite near the solution of such an important problem as the reduction of iron ore in an electrical furnace, using as reducing agent principally the ore itself, carbon and impurities of the pig iron granulated.

From this single description it seems evident, first, that in whatever shape this process is it is rather the purification of pig iron with the aid of the oxygen of the ore than a reduction of the ore. Secondly, if we consider the process, its practical economy seems very questionable on account of the small quantities of lathe scrap from pig iron, obtainable on the market at a low price. To take pig iron from the furnace and granulate it would be prohibitive on account of the expense.

Further, if a mixture is made as proposed in this paper, consisting of 54 per cent of iron ore, 27 per cent of granulated pig iron, 4 per cent of sawdust, 4 per cent of limestone, 3 per cent of tar, and 8 per cent of coke, this mixture, molten in an electric furnace, will prove a failure, as I am ready to show at any time, except if iron ore of extreme purity and granulated charcoal pig iron are used.

I further think it necessary to point out that in an article published February, 1902, in the *Revista d'Artiglieria & Genio* (Vol. 1), I described the entire series of experiments made by me during the preceding years and by which I established the most suitable form of the furnaces which were patented 1900 and 1901 and have been in industrial operation ever since, and then wrote as follows:

"After these favorable results I abandoned, without hesitation, the cupola shape, which was the original shape of my furnaces, and adopted the shallow kind. Changed in this manner the furnace, as may be easily understood, is not only suitable for treating mixtures of ore, but is likewise adapted for the refinement of pig iron in accordance with the open-hearth process, while at the same time it serves as a simple melting furnace.

"As air cannot penetrate into the furnace, the purification of the pig iron requires the introduction of oxygen in form of ore and in sufficient quantity to burn all the impurities. This is merely the common way, known in the metallurgy of iron by its English name of 'ore process.' The ore gets rid of the oxygen and the latter oxidizes the impurities of the pig iron.

"Numerous tests made with the furnace, transformed in this kind, gave evidence that anything that I had figured out a priori to be obtainable was obtained in practice. On account of the aforesaid modification I really have been able to produce, at will, malleable iron, steel, alloys of iron with other metals as manganese, chromium, nickel, etc., either by direct extraction from the ore, or by refining pig iron according to the 'ore process,' and also ingots of iron and steel by melting large lumps of scrap or fine scrap of these materials."

Hence, the refining of pig iron by aid of the iron-ore process, which after all forms the base of the Lash process, is not at all new, having been studied and experimented by me before 1900 and ever since employed industrially. It is used with my furnace at the Royal Artillery Works at Turin since spring 1903; it has been in use without interruption with the furnaces of the Electric Steel Works "Forni Elettrici Stassano" at Turin, which I fully described in my article of August last, and also with the furnace at the Bonner Fräsefabrik at Bonn, Germany (now Rheinische Electro Stahl Werke), also mentioned in my former article.

TURIN, ITALY.

ERNESTO STASSANO.



# Apparatus for Electrolytic Refining of Precious Metals.

By H. LACROIX.

In precious-metal refineries the chief endeavor has been in the past to improve the chemical and electrochemical features of the refining process, to select the best conditions of density, composition of electrolyte, temperature, acidity, etc. The mechanical side of the problem has been rather seriously neglected, so that highly perfected processes are being carried out in rather rudimentary apparatus.

The tanks employed in gold and silver refineries are almost always simple rectangular boxes, generally of wood.

chloride might be mechanically carried over onto the cathodes.

Circulation of the electrolyte is almost always employed, but the methods are generally crude, circulation being obtained by stirring or other simple means. In some cases the electrolyte is introduced into the tank at one end and flows off at the other end, but attention is hardly paid to the exact path of the electrolyte through the tank.

Theory as well as practical experience prove, however, that it is advantageous to separate the anodic and cathodic portions of the electrolyte and to maintain the density of the electrolyte constant all over the surface of the electrodes by continually bringing fresh electrolyte to the electrode surface.

These considerations have led the author to design the ap-

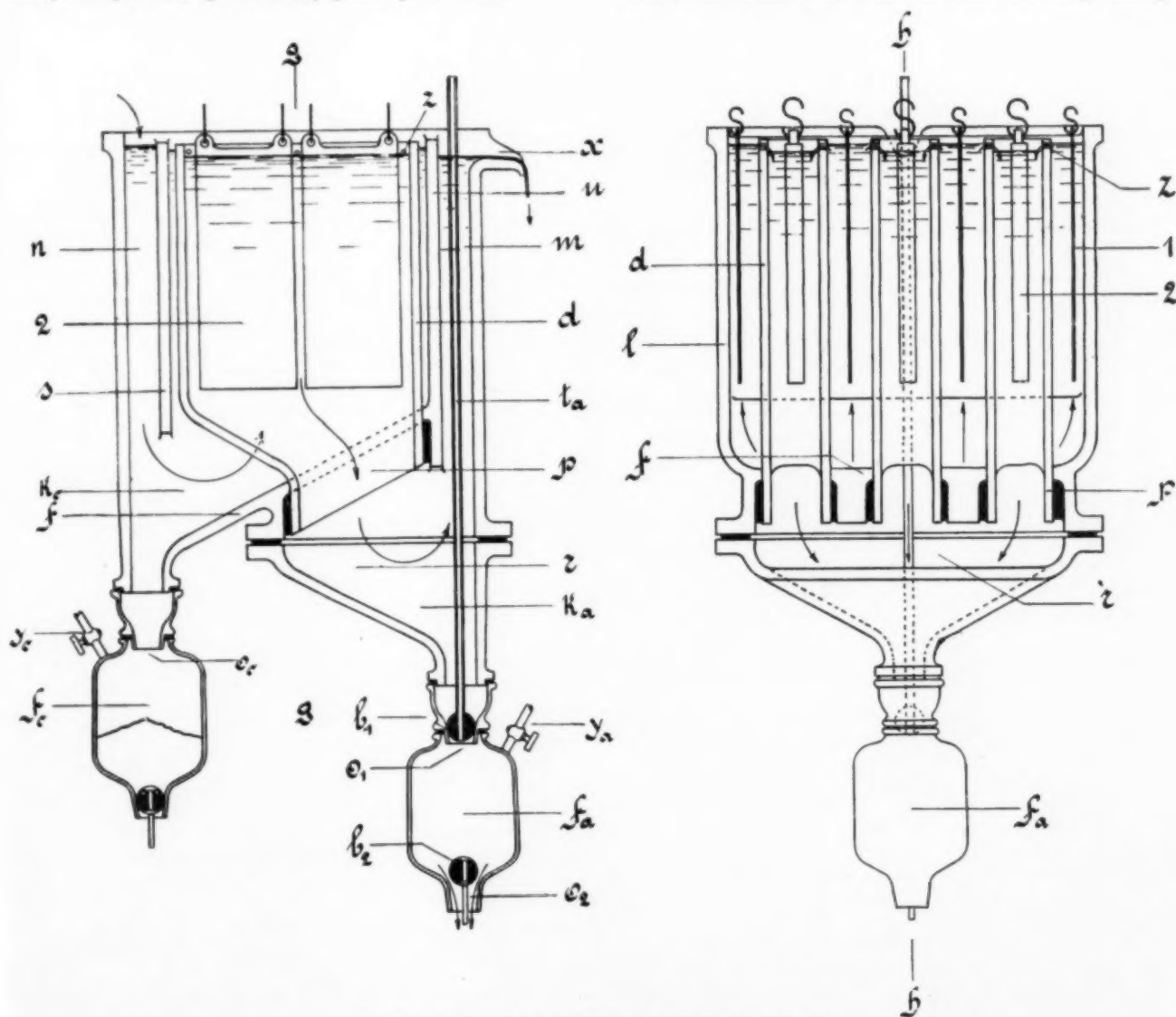


FIG. 1.—SECTIONS OF ELECTROLYTIC REFINING APPARATUS.

In the Moebius process of silver refining the electrolysis is carried out in tanks of this kind and the anodes are contained in canvas bags. The anode slime accumulates within these bags. When the anodes are consumed, the operation is interrupted and the bags are emptied. The cleaning of these bags is a long and delicate operation, which may easily involve serious losses.

The Wohlwill process of gold refining, which has been thoroughly studied from the electrochemical standpoint, is also carried out in simple tanks without diaphragm between the electrodes. On this account it is necessary to use as starting anode material an alloy containing very little silver and to employ only a slight circulation of the electrolyte, as otherwise silver

paratus shown in two sections on Fig. 1. In practice it has given so far excellent results.

The anodic compartment comprises the space within the diaphragm cells *d*, the reservoir *r*, and the exit channel *m* which leads to the overflow *x*.

The cathodic compartment comprises the space outside of the diaphragms *d* and the reservoir *k\_c* with the walls *u s* and the inclined bottom *f*. There are holes in this inclined bottom, and through these holes pass the lower parts *p* of the diaphragm cells which are thus in communication with the lower reservoir *r*.

1 are the cathodes, 2 the anodes. The anodes 2 consist, of course, of the alloy to be refined and are suspended within the

diaphragm cell. The electrolyte is in continuous circulation through the electrolyzing tank; it enters through the channel *n*, passes to the bottom of the cathode compartment, rises upward along the cathodes, passes over into the diaphragm cells through the holes *s* near the top, runs downward along the anodes into the space *r*, rises again through the channel *m* and leaves the electrolyzer through the overflow *x*.

During electrolysis the insoluble constituents of the anodes (the anode slime) fall down through *p*. The heaviest particles slide on the inclined bottom of *k<sub>a</sub>* and accumulate in *f<sub>a</sub>*. The lightest particles—those which tend to fall downward with less speed than the speed with which the electrolyte rises upward in the channel *m*—are taken along by the electrolyte to the outside of the cell and are there recovered by filtration.

Any particles of cathodic deposit which do not adhere to the cathode surface fall onto the inclined bottom *f* and accumulate in *f<sub>c</sub>*.

In this way the different constituents of the anode are automatically and continuously separated into the following parts:

- (1) Adhering cathode deposit, i. e., pure refined metal.
- (2) Non-adhering cathode deposit which accumulates in *f<sub>c</sub>*.
- (3) Heavy anode slimes, accumulating in *f<sub>a</sub>*.
- (4) Light anode slime, recovered on a filter outside of the tanks.

The flasks *f<sub>a</sub>* and *f<sub>c</sub>* are emptied as follows:

The globe valve *b*, which is normally raised above its seat or even completely removed from the apparatus, is first pushed down by means of the long hollow tube *t<sub>a</sub>* so as to close the aperture *o<sub>1</sub>*. By any suitable means, preferably by a proper receiving flask (not shown in the illustration) the globe valve *b<sub>2</sub>* is then raised and flask *f<sub>a</sub>* is emptied while air enters through the hollow tube *t<sub>a</sub>*.

When *f<sub>a</sub>* is emptied, the globe valve *b<sub>2</sub>* is replaced so as to close the bottom hole and by means of *Y<sub>a</sub>* the flask *f<sub>a</sub>* is brought into communication with an outside reservoir containing electrolyte, its level being the same as in the electrolyzing tanks. The flask *f<sub>a</sub>* is thus filled with electrolyte while the air escapes through the long hollow tube *t<sub>a</sub>*. The cock *Y<sub>a</sub>* is then closed again and communication between *r* and *f<sub>a</sub>* is re-established by raising the valve *b<sub>1</sub>*. This requires no effort, since the pressure is the same on both sides, nor does it cause any agitation nor any variation of the level of the electrolyte in the tanks.

It will be seen that the apparatus permits absolutely continuous operation, since the emptying of the flasks *f<sub>a</sub>* and *f<sub>c</sub>* and the renewal of anodes and cathodes does not require interruption of operation and may be done at any moment. For instance, it is unnecessary to wait with the removal of the anode slime until the anodes are completely consumed (which is, of course, unavoidable when the anodes are enclosed in canvas bags. This is quite an important point, since we have to do with slimes rich in gold and the interest item enters into the cost sheet.

This method of disposing of the slimes results in an operation with a minimum of loss. This is not unimportant, as an electrolyte of chloride of gold is employed, for instance, containing 30 grams per liter. The hands of the attendants do not come in contact with the electrolyte nor with any part of the apparatus which is wetted by the electrolyte.

The forced circulation of the electrolyte along the electrodes permits to maintain an absolute uniform density all over the surface and consequently results in a perfectly uniform consumption of the anode and a perfectly uniform deposit on the cathode.

In ordinary tanks without circulation or with circulation by means of stirring, the anodes are consumed in such a way as to assume the form shown in Fig. 2, the bottom part being much more quickly consumed than the upper parts. The anodes, therefore, gradually assume a wedge shape. (The dotted lines represent the original shape, the drawn-out lines the shape later on.) On the other hand, with the apparatus as described

above, the consumption of the anodes is as shown in Fig. 3, the anode being corroded equally all over the surface so that at all times the two surfaces of the anode plate remain truly parallel. This enables one to use the full current to the last moment.

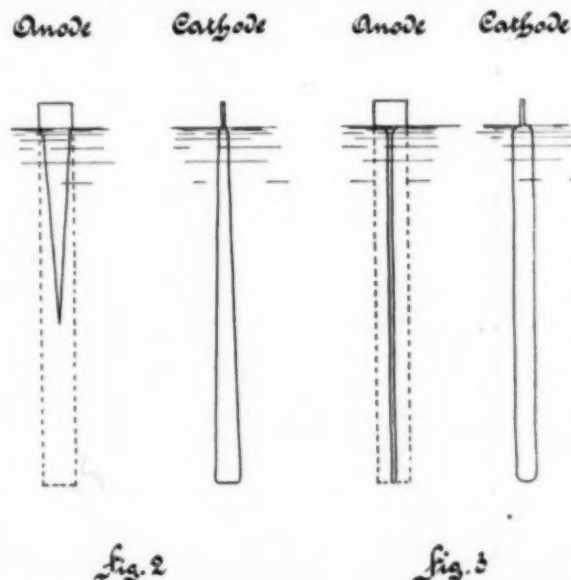
The rest, which is not consumed and which is returned to the foundry, is less than 8 per cent of the original anode weight.

This apparatus may be successfully employed for refining gold by the Wohlwill process, or silver by the Moebius process, or copper-silver-gold alloys by the Dietzel process.

As to **gold refining**, the Wohlwill process is well known and has been repeatedly discussed at length in this journal.

By the use of the apparatus described above, it is possible to treat by the Wohlwill process gold alloys relatively rich in silver (containing up to 15 per cent silver), yielding gold of 100 per cent purity at the cathode.

The particles of silver chloride which detach themselves from the anodes or are scraped off, drop into the lower reservoir *r*



FIGS. 2 AND 3.—CONSUMPTION OF ANODES AND DEPOSITION ON CATHODES WITH UNIFORM AND NON-UNIFORM DENSITY OF ELECTROLYTE.

and accumulate in the flask *f<sub>a</sub>*, from which they may be removed at will.

The electrolyte when enriched in gold in the diaphragm cells at the anode surfaces, leaves the tank through the overflow *x* and after filtration it is fed back to the tank into the cathode compartments and gives off gold to the cathodes. However this circulation may be carried out, it is impossible for silver chloride particles to be deposited on the cathode together with the gold. It is further possible, even with a comparatively high proportion of silver in the anodes, to use a current density above 10 amp per square decimeter, with sufficiently strong circulation.

In **refining silver** by the Moebius process the silver is deposited in form of crystals on the cathodes. When scraped off, the silver drops on the inclined bottom *f* and collects in the flask *f<sub>c</sub>*.

The insoluble anode slime, consisting principally of gold, falls into the reservoir *r* and accumulates in the flask *f<sub>a</sub>*. The electrolyte is returned after filtration to the cathodic compartment.

In the Dietzel process for **refining copper-silver-gold alloys** the cathodes are made of copper and the cathodic deposit consists of copper. Silver, copper and some impurities pass from the anodes into the electrolyte, while gold and other insoluble constituents drop into the flask *f<sub>a</sub>*. The electrolyte running off from the anode compartment of the tanks contains silver nitrate and copper nitrate. Outside of the tank the silver is almost completely precipitated on copper. The electrolyte





also soluble in alkalis, but their main characteristic is that if heated under proper conditions they will ultimately transform into *B* or *C*.

*B* is called the "intermediate condensation product." Chemically *A* may be considered to be the anhydride of which *C* is the polymer. At ordinary temperature *B* is also a brittle substance which can easily be pulverized. If slightly heated it softens without melting and becomes elastic, but on cooling it again returns to its brittle condition. No amount of heating will melt it, and if heated long enough it will change into *C* without losing its shape. This fact, as will be seen further on, is of extreme importance for simplifying the molding process of bakelite. *B* shows further difference from *A* because it is insoluble in all known solvents, but it swells in phenol and in acetone, without, however, entering into complete solution.

*C* is the final product, the direct polymer of *B*. It is called also "the final condensation product." It is infusible, does not even soften when heated, does not swell in phenol or in acetone, and is generally inert against chemical and physical agents.

The fact that *C* once produced cannot be molded, nor pressed, nor given any shape except by cutting, sawing, filing or turning, makes it necessary that all the preliminary work in the bakelite process has to be done with the substance in condition *A* or *B*.

We quote the following from what the speaker said on the subject of molding:

"For all plastics, like rubber, celluloid, resins, etc., the molding problem is a very important one. Several substances which otherwise might be very valuable are useless now, because they cannot be molded economically. The great success of celluloid has mainly been due to the fact that it can easily be molded. Nitrated cellulose alone is far superior in chemical qualities to celluloid, but until Hyatt's discovery it could only be given a shape by an evaporation process and its applications were very limited. The addition of camphor and a small amount of solvent to cellulose nitrate was a masterstroke because it allowed quick and economic molding.

"In the same way white sand or silica would be an ideal substance for a good many purposes could it be easily compressed or molded into shape and a homogeneous mass. But it cannot; and, therefore, remains worthless. And that is the main difference between a plastic and a non-plastic substance.

"It so happens that bakelite in *C* condition does not mold; it does not weld together under pressure even if heated; only with much effort is it possible to mold some kind of an object out of it, but some way or another the particles do not stick well together; in other terms, it is not a true plastic. Therefore, the molding problem has to be solved in the anterior stages of the process.

"I have already shown you how I am able to mold and harden quickly by pouring liquid *A* into a mold and heating it in a bakelizer. But even that method is much too slow for most purposes. Furthermore, molds cost money; any rubber or celluloid manufacturer will tell you that the item of molds represents a big portion of the cost of his plant. If an order for 10,000 pieces has to be delivered and it takes an hour for molding, it will require between three and four years to fill this order with one mold; and if the mold costs \$100, it will require \$5,000 for molds alone if the order has to be finished within 20 days. For that very reason I have devised my molding methods so as to use the molds only during the very minimum of time.

"As stated before, the use of bases permits me to make a variety of *A* that is solid, although still fusible. The latter is as brittle as ordinary resin and can be pulverized and mixed with suitable filling materials. A mixture of this kind is introduced in a mold and put in the hydraulic press, the mold being heated at temperatures preferably about 160° to 200° C. The *A* melts and mixes with the filler, impregnating everything, at the same time it is rapidly transformed into *B*. But I have told you that *B* does not melt, so the molded object can be ex-

pelled out of the mold after a very short time and the mold can again be refilled. All the molded articles are put in the bakelizer and this, of course, without the use of any molds; in this way they are finally transformed into 'C-bakelite' of maximum strength and hardness and resisting power.

"The process can still be further simplified. Instead of using pulverized *A*, we can use powdered *B* and mold it in the hot press, where it welds and shapes itself. After a very short time the *B* begins to transform into *C*, and can now be expelled from the mold. If the transformation into *C* is not complete, a short after-treatment in the bakelizer will finish everything. I have succeeded thus in reducing the molding to less than two minutes for small objects."

In the above quotation the reference was made to a "Bakelizer" and this requires a word of explanation. Dr. Baekeland has found that the best temperatures for the rapid and thorough transformation into *C* are situated between 160° and 200° C., but he has also discovered that at temperatures above 100° C. *A* undergoes a beginning dissociation which sets free  $\text{CH}_2\text{O}$  in gaseous form and this causes the formation of bubbles in the mass and renders it porous and technically worthless. By studying this tension of dissociation he was able to find a way of counteracting it by opposing external pressure until condition *C* is reached, when no such further dissociation can occur. That is the reason why he heats under artificially raised pressure, for instance, in closed molds or in a heated hydraulic press. In other instances he introduces the object in a bakelizer.

This is the name of an apparatus in which there is an interior chamber in which air can be pumped to a pressure from 50 lb. to 100 lb. per square inch. After the objects which have to be bakelized are introduced into it, then by means of a steam jacket or any other suitable heating device, they are heated to temperatures of 160° C. or higher.

In the beginning of his paper Dr. Baekeland gave a detailed description of all the scientific and patent literature which has a direct bearing on this subject, so as to differentiate clearly his own processes, which are protected by many patents here and abroad. In the United States alone he has 14 patents pending, which have not yet been published.

### Water Decomposition by Direct Current and Alternating Current, and Welding with the Oxy-Hydrogen Flame.

By M. U. SCHOOP.

Water is decomposed by direct current in the proportion of one part by volume of oxygen to two of hydrogen. This proportion is not directly suitable for welding metals, since the oxy-hydrogen welding flame should always have an excess of hydrogen.

When experimenting with alternating-current electrolysis, I found that electrolysis of acidulated water yields directly a mixture of oxygen and hydrogen gases suitable for welding. By varying voltage and frequency I always found it possible within certain limits to produce a mixture of gases which differed more or less from the theoretical ratio of 1 to 2. Unfortunately, these experiments had to be discontinued. The results of the incomplete investigation are buried in the laboratory records of a large storage battery factory.

These notes may perhaps give an incentive to others to again take up this problem. It may become possible to work out a practical method by which anybody who has electricity supply in his shop can make himself at a low cost the oxy-hydrogen gas required for welding, without using expensive electrolyzers like those of Garuti, Schmidt, Schoop, and others, in which the two gases are obtained separately.

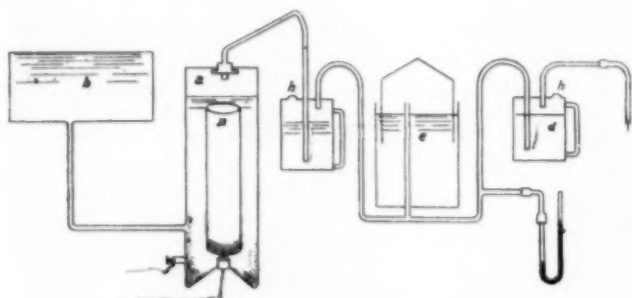
The objection may be raised that there is considerable danger in handling any, however small, volume of mixed hydrogen and oxygen gases. But it should be understood that the usual weld-

ing equipment and the ordinary water electrolyzers are free from danger. Only the electrolyzing cells operate in a safe and reliable manner, and are attended by careful and skilled laborers. Explosions of rather destructive nature have occurred, for instance, in the storage battery factories of G. Hagen, in Kalk, and of the A. F. A. G., in Hagen, Germany, in the hydrogen works in Lucerne, Switzerland, in Griesheim-Elektron, and at other places.

For many purposes it would be sufficient to use an oxy-hydrogen mixture in equivalent proportions, to which is added some atmospheric air (the nitrogen being simply inert). For instance, this would do for operating internal combustion engines, instead of using illuminating gas or gasoline. Also for welding metals of a low melting point, like lead; for illuminating and for soldering work of all kinds.

If the oxy-hydrogen gas is developed under a pressure of a water column of  $1\frac{1}{2}$  to 2 meters, it is easy to introduce the air by suction by means of an injector nozzle. In order to exactly regulate the proportion of the mixture of the oxy-hydrogen gas with the atmospheric air, the oxy-hydrogen gas could also be sucked from the electrolyzer by means of a suitable pump.

By far most oxy-hydrogen burners have the inherent disadvantage that the mixture of the two gases occurs only just before their exit, and that a perfectly intimate mixture cannot be obtained even if a mixing chamber is provided. It was evidently for the sake of safety that designers endeavored to



APPARATUS FOR MAKING OXY-HYDROGEN GAS.

shorten as much as possible the path of the explosible gas mixture in the burner, so that they did not provide a path along which the two gases would have an opportunity to mix perfectly.

But that a rather intimate mixture is very important for the temperature and quality of the flame is at once evident. In this respect an electrolyzer yielding directly a mixture of oxygen and hydrogen gases would have certain advantages.

Theory and practice show that a striking back of the flame can occur only if the speed of the gas mixture when leaving the nozzle is less than that with which the ignition is propagated. From a practical point of view this means that the opening of the burner must be adapted to the size of the flame and to the pressure of the gas. Even when using the most dangerous mixture of gases there is no possibility of striking back if the gas is emitted under sufficient pressure.

The apparatus used in my experiments was as follows: A cylindrical vessel of sheet lead, 2 millimeters thick, contained two lead electrodes of large surface (for instance, not-formed accumulator plates of the Plante type). The construction becomes one of great simplicity if, as shown in the adjoining diagram, the containing vessel *a* itself is made one electrode, say the cathode, and a lead pipe *a* closed at the bottom and open at the top, is used as positive electrodes.

*b* is a reservoir containing water to replace the water decomposed in *a* by the electric current.

*c* is a gasometer and *n* a wash bottle which holds back any acid particles which may be carried along with the gases. It is advisable to use a number of gasometers in series, a wash bottle being always inserted in the connecting line between two

gasometers. This gives a certain buffer effect. For reasons given later on, all the apparatus is made of lead. Sulphuric acid of 1.20 specific gravity is used as electrolyte.

In 1901 I made experiments with soft-lead cylinders of 60 cm length and 35 cm diameter, in order to study the effect of an explosion of an oxy-hydrogen gas mixture in such containers. The result was quite surprising. Although these cylinders were made of soft lead sheets, only 1 millimeter thick, an explosion of the hydrogen and oxygen mixture in the theoretical proportion of 2 to 1 did not result in a destruction of the cylinder. The cylinder form was simply distorted into a shape similar to that of the globe. Even a second explosion when brought about in the same container, did not result in any destructive tearing apart of the container; the result was simply a true globe, while cracks formed along the soldering seams.

It is to be regretted that I did not make analogous experiments with cylinders of other material, like hard lead or iron sheets. I have no doubt the result would have been quite different.

The oxy-hydrogen gas was used under atmospheric pressure. It is doubtful whether the result would have been essentially different if a pressure of 60 to 70 millimeters water column had been used, such as is sufficient in most cases for welding. It would seem that such soft lead containers could be usefully employed in any case where explosible gas mixtures are handled.

A simple safety device is to solder to a container of explosive gases a little lead sheet (1/5 mm) which is first torn off in case of an explosion. Such little safety sheets are marked *h h* in the diagram.

Another safety device, about which I cannot say anything, however, from practical experience, would be to surround the container with a strong wire net. It is also known that in very finely subdivided spaces, such as are obtained by a filling with iron files or glass wool, a destructive explosion cannot occur. By means of cylinders filled with glass wool it is even possible to arrest the propagation of an explosion completely.

Finally, after everything imaginable has been done to eliminate any danger of explosion, I would still advise to take out an insurance policy.

If alternating current is not available, but only direct current, it becomes necessary to remove part of the oxygen in some way, or to introduce continually hydrogen gas into the gasometer. A possible method is to pass the oxy-hydrogen gas mixture through a slightly alkaline pyrogallol solution, whereby part of the oxygen is absorbed by the solution. Physical methods of separation, for instance, by centrifugal force with very high speeds of rotation, might also be tried.

To estimate quickly the composition of a gas mixture, the simplest way is to make soap bubbles. With some experience the more or less noisy detonation indicates directly whether the composition is right for welding or whether one has too much oxygen or hydrogen. The pipe (for making the soap bubbles) is a sensitive and easy analytical apparatus. The pitch of the tone depends not only on the length of the vibrating gas column, but on the elasticity of the medium. For instance, heated air or illuminating gas or hydrogen gas give a higher tone than cold air under otherwise identical conditions. A suitable pipe is therefore an exceedingly simple apparatus for making in a few seconds a reliable analysis. In this way it is, for instance, possible to detect 1/2 per cent of oxygen in pure hydrogen.<sup>1</sup>

There can be no doubt that a simple and cheap method of making oxygen and hydrogen gases would do much to increase the popularity of the oxy-hydrogen flame for welding all kinds of metals. The transport of compressed gases in steel bottles is very troublesome, and the handling of the bottles and the valves is not without danger, in spite of all statements to the contrary.

For large consumers a liquid air plant on the Linde or Claude

<sup>1</sup> See *Sitzungsberichte der El. Ges. in Köln*, Dec. 19, 1901, paper of the author on industrial electrolysis of water. See also Victor Engelhardt's *Electrolysis of Water*, and M. U. Schoop, *Die industrielle Elektrolyse des Wassers*.

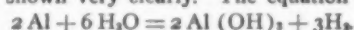


system for making oxygen gas is profitable. For small consumers the problem of making oxygen gas cheaply has not yet been solved.

The chemical methods are hardly suitable for industrial purposes. The products<sup>2</sup> hydrolithe and oxylithe, invented by Joubert in Paris, are interesting, since they are used in the same way as calcium carbide, yielding hydrogen and oxygen gases in contact with water. One kilogram hydrolithe yields 1000 liters hydrogen and 1 kilogram oxylithe 700 liters oxygen. But it is very questionable whether these substances can be made cheaply enough to enter into competition at such places where compressed hydrogen and oxygen gases are available.

With the present very low price of aluminium, namely, francs 1.30 per kilogram for aluminium ingots (12 cents per pound) and franc 0.50 to 0.60 per kilogram of aluminium scrap (4 to 5 cents per pound) it is possible to use aluminium on a large scale for making hydrogen gas. It is known that in the Japanese War the Russians made the hydrogen for their balloons from aluminium and caustic soda solution.

Under certain conditions aluminium will directly decompose pure water; namely, when its surface is freed from the ever present invisible oxide film. If an aluminium sheet is etched with mercury chloride solution, the reaction of aluminium with water can be shown very clearly. The equation is



27 kilograms of aluminium yield 3 kilograms of hydrogen, or 1 kilogram of aluminium yields 1300 liters of hydrogen.

The residue is pure aluminium hydroxide of pure white color; by selling this the cost of making the hydrogen gets very reasonable.

Care must be taken that the heat evolved during the reaction does not raise the temperature to the boiling point, since in this case the efficiency of hydrogen production drops far below the theoretical value.

Presence of small quantities of foreign metals, like copper, seems to facilitate the reaction. If turnings or other scrap are used a preliminary cleaning is, of course, necessary to remove any fat.

GARENNE-COLOMBES, near Paris, France.

### Monel Metal.

By DAVID H. BROWNE.

During the last three years the International Nickel Co. has been investigating the physical and chemical properties of a new alloy of nickel and copper which is now coming into commercial use under the name of Monel metal. This alloy has at the present time been put to so many uses and possesses such remarkable properties that a brief description of these may be of general interest.

Monel metal consists primarily of nickel and copper in the proportion of three parts of nickel to one part of copper, this being the natural proportion in which these metals exist in the largest deposits of nickel ore in the Sudbury district. Throughout its entire manufacture this alloy acts as a single metal, and while the proof is still incomplete, evidence seems to show that in these proportions nickel and copper have a remarkable affinity for each other.

Like steel, this alloy absorbs carbon, and, like steel, its physical properties are profoundly influenced not only by the percentages of carbon, silicon, etc., but by the heat treatment it receives.

A standard analysis of monel metal is as follows:

Nickel ..	68	to 72	per cent.
Iron ..	0.5	to 1.5	" "
Sulphur ..	0.014	" "	" "
Carbon ..	0.073	to 0.15	" "
Copper	to balance.		

<sup>2</sup>In this country chemical compounds, serving the same purpose, are made by the Roessler & Hasslacher Chemical Co. and known under the trade names hydron and oxone.—Ed.

This alloy is silver-white and takes a brilliant finish, which it retains indefinitely. On prolonged exposure the surface assumes a grayish cast, which may be easily removed with a polishing cloth.

In the rolled sheets, the surface assumes on heating a coating of oxide which has great resistance to acids. Samples of the rolled metal show no loss in 56 days test in pumping 40° sulphuric acid.

An especial pickle has to be used to remove the oxide coat for articles destined to be polished, but for purposes where resistance to acid is required, the oxide coating is allowed to remain.

Monel metal melts at 1350° C. It can be rolled perfectly from 900° to 1200° C., and its annealing temperature is above 875° C. It can be finished hard or soft, like sheet copper. Its specific gravity, as cast, is from 8.86 to 8.87, and when rolled from 8.94 to 8.95.

The cast Monel metal is at present made in two grades, with the following qualities:

	Grade C.	Grade D.
Tensile strength .....	70,000	85,000
Elastic limit .....	27,000	40,000
Elongation 2 inches .....	30%	25%
Reduction of area .....	35%	25%

These compare very favorably with the government specifications for carbon-steel castings, viz.:

	Hard.	Medium.	Soft.
Tensile strength .....	85,000	70,000	60,000
Elastic limit .....	38,250	31,000	27,000
Elongation .....	15%	18%	22%
Contraction .....	20%	25%	30%

In the rolled and annealed condition Monel metal is stronger than nickel steel, as the following tests will show:

	Monel metal 1-in. rods.	Average tests. Rolled, annealed and cold drawn.
	As rolled.	
Tensile strength .....	100,000	110,000
Elastic limit .....	50,000	80,000
Elongation 2 inches .....	30%	25%
Reduction of area .....	50%	50%

For comparison the specifications of steel forgings are given below:

	Carbon steel.		Nickel steel.	
	Annealed.	Oil tempered.	Annealed.	Oil tempered.
Tensile strength .....	80,000	90,000	80,000	95,000
Elastic limit .....	40,000	55,000	50,000	65,000
Elongation 2 inches .....	22%	20%	25%	21%
Reduction of area .....	35%	45%	45%	50%

Some tests of 1/2-in. rolled plates furnish an interesting comparison with soft steel and copper.

	Monel metal.	Soft steel.	Copper.
Tensile strength .....	90,000	60,000	34,000
Elastic limit .....	45,000	30,000	18,000
Elongation 2 inches .....	30%	35%	52%
Reduction of area .....	60%	35%	57%

We have here a metal possessing about 25 per cent greater tensile strength and 50 per cent greater elastic limit than the best rolled steel, with the additional quality of incorrodibility. The mechanical possibilities open to such an alloy are endless.

During the last year some 300,000 sq. ft. of Monel metal sheets were used to roof the Pennsylvania terminal station in New York City. The manufacturers, who have tested this material for roofing, state that they find it as easily worked as copper.

The sheets are silvery white, exceedingly flexible and malleable, and are handled in exactly the same way as sheet copper.

The rolled metal has been drawn into wire of all sizes down to 0.004 in. This latter is as soft and pliable as a silk thread. In the form of wire exhaustive tests have been made of the metal for window screens, bed springs, filter cloths and other purposes where its incorrodibility makes it especially effective.

In small articles, such as tacks, bolts, screws, angle braces and such stamped work as door and window trimmings, hinges, gas and electric fittings, and other small articles too numerous to mention, it is rapidly finding its way into the market.

The metal works on the lathe as well as soft steel without chattering or jumping. It has been spun and pressed into hollow-ware, kitchen utensils, watch cases, finger bowls, with the same ease as copper or silver. The superiority of such metal over nickel-plated brass, from which the coating is easily removed by polishing, is self-evident.

One of the most satisfactory uses of Monel metal is in seam-



less tubes for condensers and boilers for automobiles and motor boats. The metal draws perfectly into a smooth tube and its high elastic limit and tensile strength, combined with its incorrodibility, are of especial value in light machinery.

The largest casting so far made was a solid hub and propeller for the Southern Steamship Co.'s steamer *Creole*. This casting was 9 ft. 6 in. in diameter and weighed 6500 lb. It has given perfect satisfaction. Larger castings can be made, and as the material is much stronger than manganese bronze or Tobin bronze, it is eminently suitable for any purpose to which these have heretofore been applied.

In small cast propellers for hydroplanes or high-speed motor boats, the wheels are subjected to an enormous strain. The Hydroplane Co.'s engines turn from 1500 to 2000 r.p.m. at 40 hp. With a blade 16 in. long, 40 deg. pitch and the edge of the blade thinned down to  $\frac{1}{8}$  in. it requires an extraordinary metal to withstand the strain.

Under these conditions standard manganese bronze bends at the blade tip and becomes useless. Monel metal has been given exhaustive tests in such service and proves absolutely rigid and at the same time retains its original burnished surface.

Some of the physical constants of the metal, its electrical qualities, the effect of varying amounts of carbon, silicon, copper and iron, yet remain to be worked out. As these are investigated it is hoped to present a series of papers embodying further experience with this remarkable alloy.

COPPER CLIFF, ONT.

### Deoxidation and Desulphurization in Electric Steel Furnaces.

BY DR. R. AMBERG.

There are still people found who think that certain mysterious electric forces are active in electric steel furnaces.<sup>1</sup> As a matter of fact, any discrepancy of electric steel refining from the older metallurgical practice may be easily explained on the basis of well-known and generally-recognized principles and facts.

The extraordinarily high temperature may be considered the characteristic feature and one of the chief advantages of the electric furnace over the gas furnace. It is, therefore, interesting to compare the different systems of electric steel furnaces with respect to the degree and the distribution of the temperature within the same.

The Héroult furnace has two places of maximum temperature right below the lower ends of the two electrodes, where the arcs play between electrodes and slag. The temperature differences in the furnace cause a certain automatic agitation of the steel bath which is also influenced by the chemical reactions occurring at any moment in any place.

In the Stassano furnace the surface of the bath is heated by radiation from a central point above. Although the center of the surface gets hotter than the border, the temperature differences do not seem to be sufficient to provide the necessary agitation, since Stassano let his furnace revolve for just this purpose. The Bonner Fraeserfabrik has called my attention to the strong downward deflection of the arc, which is an essential factor in producing a sufficiently high temperature.

In the induction furnace any vertical section has a uniform temperature. Temperature differences are produced by special means, such as reducing the cross-section of the bath at certain places, or by additional "pole plates" as in the Roechling-Rodenhauser furnace. A rotation of the whole steel bath is automatically produced by the rotary magnetic field in polyphase induction furnaces.

Neither the Stassano furnace nor the induction furnace has any places of such a pronounced high temperature as the Héroult or Girod furnaces have right below the arcs.

The high temperature is of importance for two reasons.

<sup>1</sup>It is hardly necessary to discuss in detail the peculiar hypothesis of Schmid (this journal, vol. VI, 1908, p. 81), since so far he has not proven it by any facts. See also M. Haff (this journal, vol. VI, 1908, p. 96).

First, it increases the fluidity of the slag and of the steel bath and therefore facilitates diffusion and convection currents and consequently the chemical reaction between slag and steel bath. Secondly, the high temperatures cause a very high reaction velocity; at low temperatures an increase of 10 deg. C. generally doubles the reaction velocity and at the temperature of the steel bath in the electric furnace the reaction velocity is probably infinitely high.

From these viewpoints it is interesting to refer to the discussion of Geilenkirchen and Osann (this journal, Vol. VI, p. 405). In the Héroult furnace the slag has the highest temperature and is therefore very fluid, so that the reactions in the slag occur very quickly. In the Roechling-Rodenhauser furnace the steel bath is the principal source of heat and gives off its heat to the slag. Reactions in the slag alone are, therefore, not as much facilitated in the Roechling-Rodenhauser furnace as in the Héroult furnace. On the other hand reactions between slag and metal will be facilitated if these reactions evolve heat so that more heat is supplied to the slag. This is indeed the case under the conditions of actual operation.

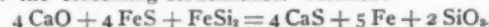
According to the Héroult patents the slag contains metallic sulphides and calcium carbide (the latter being either formed in the slag in the furnace or added). In the Roechling-Rodenhauser furnace Osann states that calcium carbide has not been found effective, probably because the temperature was too low. But if ferrosilicon is added to the steel bath in the Roechling-Rodenhauser furnace the reaction between steel bath and slag is facilitated by the greater fluidity of the slag due to the high combustion heat of silicon and the introduction of silica. Stassano also uses ferrosilicon.

The empirical formulas of the reactions by which sulphur is removed are as follows:

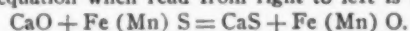
In the Héroult furnace:



and in the Roechling-Rodenhauser furnace:



The reaction which is at the bottom of these two processes is the change of FeS or MnS into CaS and appears to lead to an equilibrium, which is displaced by a small addition of metallic oxides toward the CaO side (i.e., so that the reaction of the following equation when read from right to left is increased):



Hence a curve which would represent the desulphurization as function of the FeO content in the slag does not show any sharp break, but a gradual bent when FeO occurs. In parenthesis it may be mentioned that Osann's supposition of the reversal of the reaction  $\text{FeO} + \text{Mn} = \text{SFeS} + \text{MnO}$  for 1350° to 1500° has already been proven by Schütz to take place in fact (*Metallurgie*, 1907, p. 660 to 6621).

In the electric refining processes, discussed above, any oxide is removed by the addition of reducing agents. Although both types of furnaces are built air-tight and the metal bath is protected by the layer of slag, the Héroult furnace has the further advantage of a reducing atmosphere, due to the CO set free in the reaction and to the incandescent terminals of the electrodes.

The removal of sulphur in form of manganese sulphide is made more difficult in the Roechling-Rodenhauser furnace by the strong circulation of the bath, while in the Héroult furnace the conditions are more favorable for this reaction and the highly fluid slag permits the MnS to pass to the surface. But in both furnaces the removal of sulphur in form of manganese sulphide is of much smaller importance than its removal in form of CaS.

Finally the formation of silicon sulphide, suggested by Osann (see also M. Haff, this journal, Vol. VI, p. 96), is quite possible in certain stages of the process on the basis of thermochemical considerations, though exact facts are not available. For instance, in experiments of the author (*Stahl und Eisen*, 1904, p. 394) such a strong evolution of SiO<sub>2</sub> has been observed from FeS and SiO<sub>2</sub> under the influence of an arc, that a direct evaporation of SiO<sub>2</sub> cannot be assumed.

The explanation of my experiments and of the process in the steel bath may be that ferrosilicon (which can always form under the condition of my experiments and which is added in the Roehling-Rodenhauser furnace) reacts with FeS in such a way that  $\text{SiS}_2$  is formed, evaporates and oxidizes in the air.

DUISBURG, GERMANY.

### A Practical Note on Thermoelectric Pyrometers.

BY CHARLES H. WILSON.

Those with an interest in pyrometers have, in most cases, come to know that of thermoelectric pyrometers there are two types. One is the Le Chatelier type, and it may be well to state here that Henri Le Chatelier is a French metallurgical engineer and scientist who has neither patented, manufactured nor sold pyrometers, but as a result of most careful and successful investigations has recommended a pyrometer with thermocouple of pure platinum and an alloy of 90 per cent platinum and 10 per cent rhodium, and a galvanometer of high internal electrical resistance; and in regard to this high internal resistance he expressed a preference for over 200 ohms; the object being that readings of the galvanometer would then be but negligibly affected by variations in the resistance in the thermocouple and leads as those are changed in temperature and length.

At the time when these recommendations were made Le Chatelier had to choose between galvanometers of the suspended-coil type which permitted the high internal resistance of from 200 to 400 ohms and double-pivoted millivoltmeters of from 2 to 4 ohms.

Intermediate instruments of single-pivot and double-pivot construction have recently been perfected giving internal resistance superior to 75 ohms for the low millivolt range required in connection with Pt, Pt—Rh thermocouples, and these, while sacrificing very slightly the fine accuracy of suspended-coil instruments for pyrometer work, are so much better adapted for use under industrial conditions that they have carried what is practically the Le Chatelier type into works where the suspended-coil galvanometers could not go. That these 75-ohm pivot indicators, when calibrated for a definite external resistance approximating that of leads and thermocouple, are capable of a high order of accuracy, I shall later endeavor to show.

What are designated as "low-resistance pyrometers" have, during the last few years, come widely into use. They are the logical outcome of the discovery that, while thermocouples of certain alloys of base metals will not maintain their e.m.f., and, in some cases, not even withstand the physical and chemical assault of the very high heats that the platinum-rhodium couples will meet, they will, nevertheless, withstand the more moderate heats when such base metal couples are constructed with elements of large cross-section.

This large cross-section of the wire or tubular elements of a couple give it at the same time a very low electrical resistance. Consequently if it is low in resistance, say, 0.06 ohm, the change in resistance as the couple is used under conditions varying from being heated only at the tip to being heated throughout most of its length, may still be large in a percentage way, but will be small in the abstract. If it doubles in resistance the change will be only 0.06 ohm.

This is quite a departure from the platinum couples which are made in all diameters and lengths, but which are frequently of about 2 ohms at 72° Fahr., and which change to 4 ohms when heated to 2000° Fahr. throughout nine-tenths of their length.

In the case of the Le Chatelier type it is customary, speaking of industrial practice, to disregard the resistance in the leads as they form but a small percentage of the entire circuit, say, 1 or 2 ohms out of 300, but leads resistance should be, and generally is, carefully considered in the low-resistance pyrometers and it is further kept down to the small amount of 1/10 to 1/3 ohm.

With total resistance of leads and thermocouple of, say, 1/2 ohm, a millivoltmeter of, say, 4 ohms, and calibrated for 1/2 ohm external resistance, completes a low-resistance pyrometer.

Now let us see the degree of accuracy that may be expected, based solely on the matter of intended electrical resistance in the entire circuit.

In the Bureau of Standards Circular No. 7, 3d edition, Oct. 1, 1908, is published a simple proportion expressed in this formula:

$$E_1 = E \frac{R_2}{R_1 + R_2}$$

where  $E$  = true electromotive force of a thermocouple for any assumed difference of temperature between its junctions.

$E_1$  = actual reading in millivolts on millivoltmeter or galvanometer.

$R_1$  = all resistance of thermocouple wire and attached leads not allowed for in the calibration of the instrument.

$R_2$  = resistance of the galvanometer or millivoltmeter.

Let us take a Le Chatelier type of pyrometer of which a fair example would be

$R_1 = 3$  ohms, composed of leads, 1 ohm; couple, 2 ohms.

$R_2 = 200$  ohms

Then  $E_1 = E \frac{200}{3 + 200} = 0.985 E$ .

That is to say the reading on the instrument would be 1 1/2 per cent low when the couple is heated only at the junction.

The same pyrometer with the couple heated through most of its length to about 2000 deg. F. would have

$R_1 = 5$  ohms, composed of leads, 1 ohm; couple, 4 ohms.

Then  $E_1 = E \frac{200}{5 + 200} = 0.976 E$ .

That is to say, the reading would be 2.4 per cent low.

Let us next take the same couple and leads with a 75-ohm, single-pivot indicator calibrated for 3 ohms external resistance, which means that the 3 ohms are not an outside factor, but become an integral part of the resistance of the galvanometer, i. e.,  $R_2 = 75 + 3 = 78$  ohms. When leads and couple are cool, except the tip of the couple, there is no resistance in either leads or couple not taken care of in the calibration and  $R_1 = 0$

$$\therefore E_1 = E \frac{78}{0 + 78} = E$$

In other words we should here have a true reading. But let there be no misunderstanding of the reason why with the couple cold throughout most of its length we obtain a truer reading with the 75-ohm than with the 200-ohm galvanometer. It is because I have assumed conditions of actual practice where the higher-resistance galvanometer is calibrated without reference to the resistance of couple and leads, while the 75-ohm instrument we are considering is calibrated for the actual resistance in the couple and leads, with the couple cold.

Let us now consider the 75-ohm galvanometer with the couple heated throughout most of its length to about 2000 deg. F.

$R_2$  remains = 75 + 3 = 78 ohms as before, but the increase in resistance of the couple from 2 to 4 ohms is 2 ohms, so  $R_1 = 2$ .

Then  $E_1 = E \frac{78}{2 + 78} = 0.975 E$ .

That is, the readings would be 2 1/2 per cent low, or practically the same as with the 200-ohm galvanometer calibrated in true e.m.f.

In a "low-resistance pyrometer" the resistance of the millivoltmeter will be, say, 4 ohms; of the couple when cold, 0.06 ohms; and of the leads, 0.34 ohms. Here, of course, the calibrations will take into consideration the resistance of couple (cold) and leads, so

$$R_2 = 4.00 + 0.06 + 0.34 = 4.4 \text{ ohms.}$$

If the couple when heated so much as doubles its resistance we shall have  $R_1 = 0.06$ .



$$\text{Then } E_1 = E \frac{4.40}{0.06 + 4.40} = 0.9866 E.$$

That is, the reading will be about 1 1/3 per cent low, and if the couple were heated only at the tip there would be not even that small error.

But let us see the result of combining a millivoltmeter of the general type employed in the low-resistance pyrometers with a platinum-platinum-rhodium thermocouple 3 ft. or 4 ft. long. To begin with, the electromotive force of the platinum couple is so much lower than that of the base-metal couples that to obtain full scale deflection with the former the resistance of the indicator would have to be cut to at least 2 1/2 ohms—this is a matter of instrument construction, and I do not refer to the single-pivot and double-pivot indicators used in the modified forms of the Le Chatelier pyrometer.

To give this combination every possible advantage we will assume that it is calibrated for an estimated resistance in leads and thermocouple, which will be, say, 1/2 ohm in the leads and 3 ohms in the couple, or 3 1/2 ohms in both. As the couple under different conditions of use will vary from 2 to 4 or perhaps 5 ohms, it will readily change its resistance from whatever is assumed by at least 1 ohm.

$$\text{So } R_1 = 1.$$

$$R_2 = 2\frac{1}{2} + 3\frac{1}{2} = 6.$$

$$\text{Then } E_1 = E \frac{6}{1 + 6} = 0.857 E.$$

That is, the readings will be from 14 1/2 per cent high, to the same amount low, or at 2000 deg. F. an error of 287 deg. F. must reasonably be expected except by calibration of the pyrometer with an exact knowledge of the length of couple, its depth of immersion into the heated zone and the approximate heat of the thermocouple wires where immersed.

This should answer the question that has been so often asked: Why cannot one use a platinum-rhodium thermocouple on the indicator of a "low-resistance pyrometer"? The low-resistance pyrometer and the high-resistance pyrometer are each capable of accuracy, but the mistake of uniting the thermocouple of the latter with the indicator of the former must not be made. If one indicator is needed on both platinum and base metal couples it must be the high-resistance indicator of surely not under 50 ohms.

The influence of change of resistance in the leads and the introduction of contact resistance may be estimated in the same way and it will be seen on doing so why the low-resistance pyrometer should have electrical connections soldered where possible.

### Peat and the Production of Power.\*

By HERBERT PHILIPP.

The greatest future for the extensive use of our peat bogs lies in the conversion of peat into energy for industrial purposes, either by establishing central power plants at the bog and distributing electrical energy from this center, or for industries to locate near enough to the bog to prevent the encumbrance of any unnecessary cost by the transportation of the peat.

It is barely two decades ago that the industry of Europe considered it impossible to use peat as a fuel as long as the price of coal did not exceed \$2.50 per ton, and hitherto the employment of peat as fuel for power generating purposes has been insignificant. The reasons that peat has found so little use here in North America are not because of its poor heating value, which is somewhat compensated for by the facility of procuring same, but because of the large number of failures of concerns who intended to manufacture peat for fuel purposes, their failure being due to the ill-advised large specula-

tion into processes which were mere laboratory experiments, the want of peat-drying processes of economic value or processes for using it wet, and the gasification of peat. This large number of failures made capitalists suspicious of investing in peat factories, and they were afraid to invest one cent in peat interests. However, now that in Europe such successful results are being produced, more general interest is being shown for the development of the bogs and the conversion of peat into power.

The peats found in the different bogs vary extensively and also the results obtained from same are just as variable.

Peat in the bog can contain moisture up to 90 per cent, and the separation of this large amount of water from the peat has formed one of the drawbacks in making use of peat. To-day there are several very efficient and cheap processes in use for drying peat, yet air-dried peat seldom contains less than 15 to 20 per cent free moisture, depending very much on the climatic conditions. Further drying of the air-dried peat can be accomplished by using the sensible heat in the formed gas in cases where peat is gasified, or in the flue gases where peat is used under boilers.

The ash in peat forms also an important item and is very variable, often so in the same region, and there are also equally great differences in its composition. It is rare that peat-ash represents merely the mineral constituents of the plants from whose remains the peat has been formed. It contains also mineral matter carried by the water, mechanically or chemically, which permeates the bog, and the composition of the ash is also generally influenced by the nature of the prevailing rocks in the neighborhood of the peat deposits.

To illustrate the varying ash content of peat, the following figures might be of interest: In Wood of Allen, Ireland, the peat contains 2.0 to 8.0 per cent ash. Mulder reports peat in Friesland, Germany, as containing 1 to 4 per cent ash. Peat of Baden, Germany, is reported by Petersen to contain 0.9 to 1.48 per cent ash. Maisilly states that peat from Department d'Oise, France, tests 6.7 to 14 per cent ash. In New Jersey, within 30 miles from here, there are several peat deposits which could be used for fuel purposes, testing 5 to 15 per cent ash. This ash content is very important in determining the value of a peat deposit for fuel purposes, and it is always desirable to make a large practical test for the ash in investigating a peat bog for its value as a fuel.

The composition of the ash varies greatly, as has been stated, yet in the majority of the fuel peats which have come to my attention the ash contains 80 to 90 per cent silica, traces of sulphur, except from salt-water peats, which generally contain large quantities of sulphur, also alumina and small quantities of lime, showing that there is very little in the ash to form clinkers.

In determining the calorific value of peat it is better to make direct determinations in a calorimeter than to rely on Dulong's formula, as determinations by this formula invariably give results 6 to 10 per cent too low.

We have two distinctive ways in using peat for power and heating purposes: firstly, by firing peat direct under boilers or into furnaces; and, secondly, by gasifying peat.

For **direct firing** peat is used in large fist-size pieces or in the form of briquettes. Peat which disintegrates very much on drying has to be briquetted, especially if it has to be transported any distance from the factory, which is done without any additional binder and at a very low cost. In cases where the peat disintegrates and dusts easily, it can be, if used at the factory, effectively burned under a boiler by a powder-firing apparatus.

For firing on grates several characteristic properties of peat have to be taken into consideration. Peat is specifically much lighter than coal, and requires more work to keep an efficient heavy fire bed than when coal is used. This also increases the labor for hand-firing, not only because the heating value of the peat is slightly less than coal, but on account of its bulkiness

\*A paper read at the meeting of the New York Section of the American Peat Society, Feb. 13, 1909.



one man cannot fire the same amount of peat in a given interval as he could coal. These difficulties are overcome by using a step-grate with mechanical feeding, as is stated below. The grate bars on an ordinary grate have also to be placed closer together, because peat ash does not generally clinker and the ash would fall into the pit too easily and then the burning peat which disintegrates easily, would fall through and a considerable loss would be sustained by the unconsumed carbon in the ash.

The step-grate is very decidedly more economical for the firing of peat direct under boilers, or even for the direct firing of open furnaces, and the addition of apparatus for the mechanical feeding of peat can be used more effectively than with the plain grate; neither is there so much loss of heat sustained by unconsumed carbon falling through the grate bars, yet the loss of heat in the ash is as great as in the other.

The moisture of air-dried peat for fuel purposes is on an average 15 per cent, and in Sweden<sup>1</sup> practical use of the sensible heat of the flue gases is made to expel more moisture. In Timsfors and also in Rydboholm the flue gases circulate directly around the peat in a specially constructed oven. In bad weather, when the chimney draft is poor, fans are used to draw the off gases through. It is best to have two such ovens, which are then used alternatively.

Peat briquettes generally show a slightly higher value in heat units than the unbriquetted peat. Samples of American peat fuel with 12 to 18 per cent moisture have shown 9000 to 10,000 B.t.u., and if the peat is dried better by artificial means it shows 10,500 to 11,500 B.t.u. and over. This is very favorable, as coal used for industrial purposes has generally only from 12,000 to 13,000 B.t.u. Taking into consideration the low price per unit that peat costs when used at place of production, it fully compensates for the missing heat units.

Of course, enough peat has to be dug up in the seven or eight working months to keep a power plant fully supplied for the balance of the year; this is rather a drawback as it necessitates the erection of large storage sheds to house the peat in. One thing is of interest in regard to the storing of peat, and that is that a pile of peat does not suffer from the possibilities of spontaneous combustion as is the case in storing coal.

We now come to the **gasification of peat**, which can be divided into two chapters: Dry distillation of peat (external heating), and, secondly, the gasification of peat by internal combustion.

The **dry distillation** or coking of peat was tried very many years ago, but failed on account of the peat-coke being too soft for metallurgical uses. The Swede Ekelund was the first one to obtain the condensation products from dry distillation of peat and to use the distillation gases for heating purposes, but owing to the poor grade of coke he obtained and fluctuating prices of the condensation products, he did not follow his work any further.

A few years later the German, Martin Ziegler, started practically the same process as Ekelund had given up, but through his previous experience with soft-coal distillation and more perseverance he has built up a successful and practical process. Ziegler obtains a hard coke, which finds use in metallurgical processes, by using a very dry peat briquetted under high pressure; and all of the condensation products are purified or used as raw materials in other processes. The uncondensed gases are used for heating his retorts.

Although Ziegler deserves much credit in achieving success in the distillation of peat, it can hardly be considered as a factor in the production of power from peat. Yet the production of coke in conjunction with a gasification plant by internal combustion would form a plausible and practical possibility.

I shall now pass on to the very important and interesting subject of the gasification of peat by internal combustion.

The gasification of peat by internal combustion can also be classified under two heads: The production of producer gas

from dry peat, and the production of producer gas and ammonia recovery from wet peat.

The production of **producer gas from peat** is not so very new, as since about 1872 the Motala Steel Works, in Sweden, have been using producer gas made from peat. The peat gas costs them somewhat more than coal gas would, owing to the fact that same has to be transported across Lake Wetter in sailing vessels and then by railroad to the works, but on account of the negligible amount of sulphur and phosphorus present they find it desirable in their open-hearth and puddling furnaces. In their rolling mill it is especially noted that thin steel plates scale less when fired with peat gas.

The making of peat producer gas is governed by similar laws and rules as in the manufacture of producer gas from coal. There are several well-known systems for gasifying fuel which differ chiefly in shape and in position of air and steam inlets. In producing this gas from peat we require a large fuel bed, varying in size from 5 ft. to 8 ft., according to the specific gravity and size of peat used.

The size of the peat should not be too big and it does not harm if it disintegrates, as long as it does not become too dense to prevent the steam, air and formed gases from passing freely through the firebed. In fact, the finer divided the fuel and the greater the depth, the more favorable are the chances for the formation of a high per cent of carbon monoxide. In cases where fuel-beds of necessary depth cannot be obtained, or where peat with low specific gravity is used, the formation of carbon monoxide can be enhanced by reducing the velocity of the gases; in other words, by a weaker draft and blast, thus prolonging the contact of the gases with the fuel-bed.

The air and steam entering the producer come in contact with incandescent peat and form carbonic acid and hydrogen. The heat generated by this reaction is taken up by this mixture of gases, which heat again is absorbed by the peat above this incandescent zone. The carbonic acid and hydrogen are converted into carbon monoxide, and partly methane, by the glowing carbon. The top zone is, however, hot enough to liberate and decompose many of the condensable peat products into combustible gases. We, therefore, find olefiant gas in peat producer gas.

The peat gas from the producer has still a high temperature, and this sensible heat can be very valuably used by further drying the air-dried peat, which is being fed to the producer. This can be accomplished either by bringing the peat directly in contact with the gases as it is uniformly fed into the producer, or by indirectly circulating the hot gases round ovens constructed of sheet iron.

Points for the efficient working of a peat-gas producer are a high temperature in the first 3 ft. or 4 ft. of the fuel bed, regular feeding of the peat, feeding the correct proportion of steam and a good air blast, both of these latter at a low pressure.

A good average peat gives 40 cu. ft. to 45 cu. ft. producer gas per pound of peat (dry), with a heating value of 160 to 200 B.t.u. per cubic foot.

I now arrive at the gasification of wet peat. Some two or three years ago, at the instigation of Mr. Mond of England, Frank and Caro undertook the study of the **gasification of wet peat** in the Mond producer and the **recovery of the peat nitrogen content as ammonia**. Satisfactory results have been obtained in these producers in England, Germany and France; and Woltereck reports, by a similar process, to have also obtained good yields.

Inasmuch as descriptions of these processes have been extensively published, I shall not go here into details. Peat containing 50 to 55 per cent water is used and in the tests carried out at Stockton and Winnington 70 per cent of the nitrogen in the peat was recovered as ammonium sulphate.

The favorable results of Frank and Caro have already induced capitalists to erect a Mond gas plant for peat gasification and ammonia recovery at Herne, in Westphalia, Germany.

<sup>1</sup> Scheiber. Oest. Moorstach. 1908, p. 161.

The plant at Mont Cenis colliery, in Westphalia, has been designed and erected by the Power-Gas Corporation, Ltd., of England, who have been experimenting for many years to apply the Mond process to the gasification of peat. The success which has marked their endeavors has been so favorable that three installations are now nearly completed: one in the County of Norfolk, England; one in Italy and the third in Germany. Results, which they have published, state that the peat with 40 to 60 per cent moisture was used, and per ton of dry peat, containing 1 per cent nitrogen, gasified, they obtained about 80 lb. sulphate of ammonia; 80,000 cu. ft. to 85,000 cu. ft. of good power gas, testing 150 B.t.u. per cubic foot.

Another large installation for the gasification of peat and recovery of ammonia, by this same process, is now in course of erection in the northwest of Germany. This central generating plant, which controls about 16,000 acres peat land, intends to distribute electrical energy over a wide area for agricultural purposes, as also for the provision of light and power in a number of towns situated within a radius of 40 to 50 miles from the power plant.

It is estimated that by means of the large gas engines work to the extent of 600 hp-hours will be obtained from each ton, while the value of the ammonia recovered is estimated to yield a good interest on the investment.

The vast peat resources in North America are undoubtedly well known to all, and the fact that many of the deposits are situated where the price of coal almost demands their utilization to-day should stimulate capitalistic judgment into developing this profitable industry for their own and the public's benefit.

I should still like to mention that the majority of peat deposits in North America show a higher heat value than the European deposits are reported to have, so that we can only look forward to more favorable results than are obtained abroad.

### Reduction of Refractory Oxides, Production of Ferro-Alloys and Formation of Carbides.

Several interesting electric-furnace researches have recently been carried out at the Electrochemical Laboratory of the University of Manchester at the suggestion of Dr. R. S. Hutton. While the complete accounts of these researches may be found in a number of papers by H. C. Greenwood, R. E. Slade and J. N. Pring, in the *Transactions of the (British) Chemical Society*, 1908, vol. 93 (pages 1484, 1496, 327 and 2101), the following summary of the results obtained will prove interesting.

The object of the first research of Mr. HAROLD CECIL GREENWOOD was to determine the temperatures at which carbon begins to reduce some of the more difficultly reducible metallic oxides. The mixture of the oxide with carbon was heated in an electric tube furnace. Temperature measurements were made with the Wanner optical pyrometer.

The temperature at which reduction commenced was gaged by the commencement of the evolution of carbon monoxide from the mixture of oxide and carbon. A serious difficulty was encountered due to gas which is occluded by the carbon, and which is gradually given off as the temperature is raised. It was found, however, that if the temperature were raised in small steps and maintained constant for some time at each, the increment of pressure due to occluded gas in a given time was practically constant for different temperatures.

The method for estimating the rate of gas evolution finally adopted and followed in all the experiments consisted in maintaining the tube at a constant temperature for five minutes and observing the rise of pressure during the interval. At the end of each interval the pressure was reduced by rapid evacuation during the next minute and the temperature then raised to another value, at which it was maintained for five minutes, and so on.

The rate at which gas is evolved from the carbon depends, first, on the difference in temperature between each step, and, secondly, on the length of time the carbon has been maintained at a constant temperature. Of course, the increase in pressure on raising the temperature is to some extent due to expansion as well as to the actual gas evolution. This effect, however, is approximately constant for each temperature step, and is only small, as to the average temperature of the gas probably does not exceed 200° when the carbon tube is heated to 1500°.

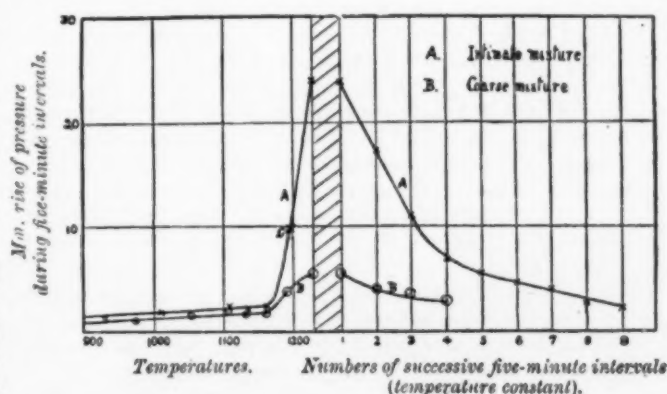
When the reduction temperature of the oxide is attained the gas evolution shows a marked increase.

When the temperature is maintained constant a little above the reduction point the gas evolution gradually dies away on account of the decrease of contact surface as reduction proceeds. As regards the fixing of the temperature at which reduction commences, the following convention was used: If there be a sharp jump from a pressure rise of, say 2 mm in five minutes to one of 10 or 20 mm, the reduction temperature is taken as the mean of the two temperatures; but if at three successive temperature steps the rises in temperature are such as 2, 5, 15, then the middle temperature is taken as that of initial action. With temperature steps of 20 to 30°, this method gives quite concordant results.

The oxide most carefully studied was chromium sesquioxide. Some preliminary experiments showed that reduction commenced at about 1200°. The material used was Merck's "extra pure" chromium sesquioxide, which was intimately mixed with a good quality retort carbon in approximately the theoretical proportions. The reduction temperatures estimated from three careful experiments with these materials were 1180°, 1185°, and 1195°, respectively.

The product contained small globules of metallic appearance, fairly uniformly distributed through the cross-section of the central portion. Quantitative reduction was never obtained on account of the limit to the intimacy of admixture attainable with retort carbon (the temperature not being taken much above the reduction point).

With an intimate mixture of chromium sesquioxide and retort carbon the temperature was gradually raised to a value slightly above the reduction point (to 1230°) and maintained constant there, the increments of pressure during successive five-minute intervals being noted. The way in which the rise of pressure increases and then falls off is shown in the adjoining illustration (Curve A).



DETERMINATION OF REDUCTION TEMPERATURES.

Another experiment was next carried out under exactly similar conditions with a mixture of chromium and sesquioxide and coarse retort carbon in the same proportion as before.

In this case the pressure began to rise at about the same temperature, but the extent of the reaction was much more limited. Even on afterward raising the temperature to 1300° the gas evolution was small. The great influence of this intimacy of mixture is shown in the illustration, and would seem to point to several important conclusions.



The temperature at which the gas begins to be evolved is that of which reduction by carbon takes place, and is not a mere process of dissociation.

Further, the falling off of the gas evolution and the incompleteness of the reduction is due to the decrease of contact surface between oxide and carbon. In the experiment with the coarse carbon the reduction could be very plainly seen to be limited to the actual surface of the carbon granules, which were coated with a metallic mirror. This last fact also indicates that the reduction is really effected by carbon, and not by any hydrogen or carbon monoxide present.

The chief results of the investigation carried out in this way are as follows:

It is shown that the reduction temperatures of the oxides of **chromium** (1185°), **manganese** (1105°), **uranium** (1490°), **silicon** (1460°), **zirconium** (1400°), and **thorium** (1600°), by means of carbon, are far below those which are generally supposed to be necessary for the production of these metals from the oxides.

These reductions commence very sharply at a given temperature, but the progress of the reduction depends greatly on the intimacy of contact, and thus on the degree of subdivision of the oxide and carbon.

The reduction temperature is found to alter on using different varieties of carbon. In some cases differences are also indicated between samples of the oxide prepared under varying conditions, but the effect can be shown to be due to the physical state of the oxide.

In all the cases studied the reaction takes place long before the melting point of the oxide is reached, and the product of reduction is also in the infused state.

Experiments to measure the temperature of dissociation of these oxides indicate that they are extremely stable (even in a high vacuum) up to temperatures far exceeding the reduction point by carbon.

\* \* \*

The reducibility of **magnesium oxide** by carbon was the object of an investigation by Mr. ROLAND EDGAR SLADE. His research seems to prove satisfactorily that magnesia is reduced by carbon, not only at the high temperature of the electric arc, but as low as 1700°.

Watts (Trans. Amer. Electrochem. Soc., 1907, 11, 279) mentions the fact that carbon can be volatilized from a bed of magnesia, and he obtained sublimes consisting of intimate mixtures of magnesium oxide and carbon.

Slade's work shows clearly that the metal can be isolated, although under ordinary conditions re-oxidation of the magnesium is effected by the carbon monoxide, for if some device is used for removing this gas, for instance, by working in a vacuum, by absorption of aluminium, or by a rapid stream of hydrogen, then metallic magnesium is obtained. The condensed magnesium is always associated with small quantities of a carbide, which, on treatment with water or dilute acid, gives off acetylene.

\* \* \*

The well-known effect of the presence of other metals in the reduction of refractory oxides by means of carbon for the **manufacture of ferro-alloys** has been the subject of a second investigation by Mr. HAROLD CECIL GREENWOOD.

While it is very difficult to produce elements such as chromium and silicon by direct smelting of the oxides, the production of ferro-alloys from a mixture of the oxides with ferric oxide is a comparatively simple matter. To account for this behavior several causes can be suggested: the greater fusibility of the alloy, or the local increment of temperature due to the oxidation of carbon by the ferric oxide, or some definite chemical affinity between the two metals. Some experiments conducted with silica led to a somewhat lengthy investigation of the problem.

**Influence of Iron in the Reduction of Silica.**—A preliminary experiment, using a mixture of purified sand, retort car-

bon, and electrolytic iron powder in the proportion 20:8:30, respectively, indicated that the reduction commenced at a much lower temperature (about 1200°) than with silica and carbon alone (1460°). This fact seemed so striking that the matter was closely investigated.

The experiments of the author leave no doubt that the presence of metallic iron exercises a remarkable influence on the reaction between silica and carbon. The exact temperature at which action commences is, as might be expected, not so sharply defined as in the simple reduction of an oxide. The experiments also point to the conclusion that in the reduction of a mixture of the oxides of iron and silicon the influence of the iron is exerted after reduction (which takes place at a comparatively low temperature), and not through the heat developed in the process.

**Influence of Ferric Oxide on the Reduction of Silica.**—With the idea of gaining more light on this point, an experiment was carried out with a mixture of silica, retort carbon, and ferric oxide. The temperature having been raised to 1130°, the product was heated in chlorine, when only a slight turbidity due to silica was obtained. This would indicate that ferric oxide does not exert any appreciable influence on the reduction of silica before itself undergoing reduction. The fact that the reduced iron had produced so little reduction was probably due to its poor contact with silica.

**Effect of Metallic Manganese on the Reduction of Silica.**—The effect of metallic manganese was also investigated. With an intimate mixture of purified sand, retort carbon and metallic manganese (free from aluminium and sodium) reduction commenced pretty sharply about 1100°, the temperature being raised to 1200°.

**Effect of Copper on the Reduction of Silica.**—It was hoped that by using a mixture of purified sand, retort graphite, and copper powder, it might be possible to collect any silicon formed by its solution in the molten copper. Reduction commenced at about 1250° and the temperature was raised as far as 1340°. The result, however, was disappointing, as the copper had not fused together, but a gray residue was left which was attacked only with difficulty by nitric acid, the copper having probably formed silicide.

Referring to the three suggested causes for the influence of the presence of ferric oxide on the reduction of oxides by carbon, these experiments seem to show that local raising of temperature by reduction of ferric oxide does not play an important part. Probably direct affinity between silicon and the metal accounts for a good deal of the action, especially as the products (with iron, copper, and manganese) were only difficultly fusible.

**Influence of Iron on the Reduction of Chromium Sesquioxide.**—The above experiments with silica led to an investigation in a similar way of some other oxides from which ferro-alloys are produced technically. Starting with chromium sesquioxide, a mixture with retort carbon and metallic iron (electrolytic powder) was taken. Contrary to the experience with silica, the mixture behaved just as if iron were absent, giving a sharp reduction point of 1190°.

**Effect of Ferric Oxide on the Reduction of Chromium Sesquioxide.**—On the supposition that ferric oxide might have some specific action, an experiment was performed, using a mixture of retort carbon with ferric oxide and chromium sesquioxide, the temperature being raised to 1130°. Curiously enough, the residue was yellowish-brown and was unaffected by acid (except for the metallic iron present) and by boiling with permanganate. Thus it was not found possible to isolate the metallic portion (which, moreover, seemed to be present only in small quantity). Probably what had happened was that ferric oxide was first reduced to ferrous oxide, which combined with chromium sesquioxide to form the brown spinel ( $\text{FeO} \cdot \text{Cr}_2\text{O}_3$ ), only the excess of ferrous oxide being further reduced to metal.

Judging from these experiments, neither iron nor its oxides



facilitate the reduction of chromium sesquioxide below its ordinary reduction temperature. At higher temperatures the solvent action of the iron may have some effect in preventing re-oxidation.

**Effect of Metallic Manganese on the Reduction of Chromium Sesquioxide.**—Using instead of iron a mixture of metallic manganese with chromium sesquioxide and retort-carbon, reduction seemed to commence about  $1120^{\circ}$ . The temperature was raised to only  $1150^{\circ}$ , but the residue on examination appeared to contain very little unreduced chromium sesquioxide. Another experiment in which the temperature was raised to only  $1140^{\circ}$  gave a similar result. On extracting the metallic portion by boiling with permanganate and treating as in the iron-chromium oxide experiments, the product appeared quite free from chromium sesquioxide under the microscope, and dissolved in hydrochloric acid to a bright green solution, evidently containing a high percentage of chromium.

There is, then, little doubt that the presence of metallic manganese to some extent facilitates the reduction of chromium sesquioxide by carbon.

**Effect of Iron on the Reduction of Manganous Oxide.**—On heating manganous oxide (the oxide reduced in pure hydrogen being used) with retort carbon and electrolytic iron, the gas evolution became very marked at  $1030^{\circ}$ ; the temperature was raised to  $1055^{\circ}$ . The metallic portion, which had slightly fused, was isolated by washing with dilute sulphuric acid, when manganous oxide is much more easily attacked than the metal. The residue under the microscope appeared quite free from any green oxide, and on testing gave the reactions of manganese. In this case, then, iron appears to exert some influence on the reduction.

The alloys formed by chromium and manganese with iron are more fusible than the silicon alloys, so that the part played by the solvent action of the iron may be rather greater than with silica.

\* \* \*

The formation of carbides has been the subject of an investigation of Mr. JOHN NORMAN PRING.

In view of the fact that the carbide-forming elements are, in many cases, known to react with carbon monoxide and other carbon compounds, considerable discussion has recently been evoked as to whether these elements can combine directly to form carbides in the absence of such gaseous impurities.

This question has now been cleared up by Mr. Pring for silicon, aluminium, iron, and magnesium. The chief results are as follows:

**Silicon.**—The direct union of pure silicon and carbon in a vacuum commences between  $1250^{\circ}$  and  $1300^{\circ}$ , the reaction proceeding rapidly above  $1400^{\circ}$ .

Commercial silicon containing 5 per cent. of iron and 0.7 per cent. of aluminium reacts with carbon at all temperatures above  $1200^{\circ}$ .

The presence of iron does not apparently facilitate the reaction, nor does carbon monoxide exert any influence between the limits of atmospheric pressure and 0.03 mm; hence, already below its melting point, silicon is proved to combine with carbon.

**Aluminium.**—This element unites directly with pure carbon in a vacuum at its melting point ( $650^{\circ}$ ), forming aluminium carbide ( $Al_4C_3$ ), and the velocity of the reaction increases with the temperature, proceeding rapidly above  $1400^{\circ}$ .

**Iron.**—Direct union with carbon occurs at about  $700^{\circ}$  under a pressure of about 0.05 mm.

**Magnesium.**—Evidence is forthcoming to indicate the formation, to a limited extent, of a new carbide below  $600^{\circ}$ , this compound giving some saturated hydrocarbon (probably methane) on decomposition with water or acids. At higher temperatures the reaction apparently ceases. This unstable compound is probably  $Mg_2C$ , of an analogous nature to  $Al_4C_3$ ; the only carbide of magnesium,  $MgC_2$ , hitherto known corresponds with the carbides of the alkali and alkaline earth metals.

## Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

### The Faraday Society.

In the discussion of Mr. E. A. Ashcroft's paper, on Dec. 21, 1908, on "The Influence of Cheap Electricity on Electrolytic and Electrothermal Industries," Mr. W. R. Cooper maintained that the cost of water power was determined by its market price and was not likely to have a fixed value. The price of water power not being always commensurate with its value, such power should be purchased outright and not merely leased.

Mr. Bertram Blount considered that other sources of power, although more costly, had, under some circumstances, very great advantages, and the idea that power at a very low cost was essential for all electrochemical industries was not correct. There is much national selfishness abroad which impedes industries. The electric distillation of zinc will come; and the low cost of energy is of less importance than the economy of applying it. This paper had been based on the calculation of the cost of power. For the prosperity of an industry he thought that a preferable method of treating the subject was to have the thing under one hat rather than to have a power company and a user.

Mr. W. Murray Morrison thought that steam power could be had at a very much cheaper rate than that stated by the author, and that labor charges had been understated. No engineer would dream of putting capital into a scheme at £168 per electrical horse-power. Moreover, when capital charges were low, depreciation was high. Labor troubles and freightage, too, demanded consideration. Every scheme differed in some respect from another, and each must be considered on its merits.

Mr. Leon Gaster said that water power at Niagara was dear because only a small part of the power could be utilized. The cost of a gas or oil plant depended on its size. He deprecated the attitude of the Norwegian government toward foreign capital.

Mr. Charles Weiss considered that the conditions of the development of water power in the highlands of Bavaria were of considerable interest.

Mr. H. Borns pointed out that inconstancy of supply was only one of the disadvantages of water power.

Prof. H. Smith referred to frequent difficulties caused by ice. He was of opinion that the author's figures both for power and for depreciation were understated.

Dr. E. Feilmann thought that peat fuel might supply the means of effecting very cheap power-gas schemes. Experiments on a large scale were being made on this question.

Mr. E. A. Ashcroft replied that his chief object had been to point out that especial sources of water power were still, although not frequently, to be acquired, and to compare the different means of producing power. He maintained the accuracy of his figures. There were no troubles from ice in Norway.

Some remarks on the subject of water power by Mr. James Swinburne in his presidential address to the Institution of Electrical Engineers, in December, 1902, are deserving of reproduction. He said: "Ricardo's theory of rent is applicable to water power as well as to arable land. If steam power costs a farthing a unit, and if water power at the same place can be produced for half a farthing, after paying working expenses and interest, the owner of the water power will claim the odd half farthing as rent, or will just allow the water power enough to encourage the production of a new thing. As a rule, however, a water power is not where it is wanted industrially. \* \* \* The result is that water power cannot command the same price as steam or gas. \* \* \*

"As a matter of fact, the cost of power is a much smaller item in most industries than is generally supposed, and it does not pay to start a works in an otherwise not perfectly suitable locality simply for the sake of cheap water power. \* \* \*

Against the cheaper power we have to put extra carriage for materials and for coal—which is often needed in addition—and extra carriage for finished products, and very often extra cost of labor, as labor is often dear and bad in water-power districts. Let us take, as an example, calcium carbide. The general idea is that the electrical energy is practically the whole cost of the carbide. Taking present practice, however, a kilowatt makes, say, two tons of carbide a year. The difference between power at, say, £2 10s. and £5 a kw-year is thus £1 5s. a ton in cost. The price of carbide may be taken as £13 10s. per ton; so, doubling the cost of power instead of nearly doubling the price of the carbide would increase it a little more than 10 per cent.

"In the case of electrolytic caustic and bleach \* \* \* for one ton the electrical energy taken at £2 10s. per kw-year—a low water-power cost comes to about 17s. 6d. The caustic and bleach sell for about £20. Doubling the price of power, therefore, increases the price some 5 per cent. For a water power to be really valuable it should be near a source of material, on the sea, and should have a great head of water so that the capital cost of development is small. Such a water power is very valuable to the landlord. A blast furnace is more valuable than a water power. There are plenty in England. But the owners who have been wasting the gas up to now will not give it away; they will want rent, so that it will only just pay to use their gas rather than make it. The electrical industry thus does not gain, but the ironmasters do."

#### THE ROYAL SANITARY INSTITUTE.

##### The Purification of Water by Ozone.

On Jan. 13 Dr. Rideal read a paper on this subject before a full meeting. He described how the ozone process after early experiments had been employed at Berlin, Wiesbaden, Paderborn and Nice, and later installed at the St. Maur municipal water works, supplying Paris, were the De Frise ozonizer is being used.

The discussion was opened by Prof. H. Robinson, who said he thought Dr. Rideal did not appreciate the comparative conditions of London and Paris. Paris water was very impure; and it was not possible to compare St. Maur water with Thames water. Additional works would be required, as in the case of London it was a matter of quantity rather than of quality, this being satisfactory. It was entirely a question of efficiency and cost. Hitherto nothing had been done with ozone in England, but there might be a better opening in the future.

Col. Davis remarked that suspended matter caused waste of electrical energy, and filtration was necessary, which—it was agreed—required minute supervision. A process was wanted which did not require much attention.

Mr. A. J. Martin said that no process could go on without supervision. Bacteriological examination was necessary. Gas was constantly examined. How much greater was the need for examination of water? He asked the annual cost of working the plant, if filtration could be dispensed with, and if the apparatus could be readily installed in case of urgency.

Dr. Nash (Medical Officer of Health for Norfolk) thought that Dr. Rideal's experiments should be repeated, and when confirmed should be considered by water authorities.

Mr. Easton Devonshire, chairman of Antwerp water works, stated that the St. Maur water was not supplied in bulk for Paris. The filters were not used regularly, but only for experimental purposes. Conditions for analyses required standardization. Water kept for a long time showed an immense increase in the number of bacilli, and Paris water was sometimes stored for 15 days as against two days for London. The water from the Ivry works was practically sterile; there were no B. coli in 1200 cc. The spring-water supply of Paris had caused typhoid epidemic and contained three times as many microbes as the river water, yet there was prejudice against river water. Ozone changed the color of river water to that of spring water.

Mr. Aglio Dibdin remarked that the Otto process obtained the first prize at Paris in 1908, and it was proposed to install apparatus to sterilize 10,000,000 gal. per day so that with this and the De Frise installation a total of 20,000,000 gal. per day would be dealt with. There were already 10 Otto installations at work on the Continent. It was impossible to thoroughly test all the water entering the London mains, and Dr. Houston had not found typhoid germs in London water.

Mr. E. B. Barnard (chairman) did not propose to ozonize the London water and so increase the cost, although he quite appreciated the utility of the process in an emergency. Its cost would be £250 per day, or £90,000 a year. He regarded the present water supply of London as a refined article. Water was purified by storage in the reservoirs. The health of London was good, even if we could not meet the wishes of some people as to analytical details.

Mr. H. C. H. Shenton drew attention to the fact that the first announcement of Dr. Rideal's paper indicated that the purification of water by other chemical means would be dealt with; and he regretted that the author had not said anything concerning electrolytic hypochlorite. Dr. Rideal was the only person present who could speak from experience on this subject, but conclusions and deductions can be drawn from results he obtained at Guildford and Maidenhead 12 years ago. Chemically prepared hypochlorite was not nearly so efficient as the electrolytic product. In comparing the cost of sterilization by electrolytic hypochlorite with that of ozone it should be remembered that the figures for hypochlorite referred to sewage effluent as against Paris water for the ozone.

Drs. Kanthack and Rideal found that one gram of available chlorine in the form of electrolytic sodium hypochlorite would sterilize 1.21 cu. m of settling tank effluent or 1.5 cu. m of filtered effluent. Now, in any good electrolyzer 1 kw-hour (1 B.t.u. = Board of Trade unit) will give from 152 to 200 grams of available chlorine. Taking the lower figure, this is equivalent to 24.95 B.t.u. per 1,000,000 gal.; while 133 B.t.u. are consumed in the ozone process for the same quantity of liquid treated. Nothing remains to be said for the ozone as compared with electrolytic hypochlorite except the cost of salt for the latter (1 penny for 10 lb. in London); but in both cases capital outlay, maintenance and depreciation have been taken into account.

Mr. W. Pollard Digby, who was engaged in the Guildford and Maidenhead experiments, had told him that his records show that in 1896 to 1898 he was producing electrolytic hypochlorite at an inclusive cost of 15d. per kilogram of available chlorine, making the cost of complete sterilization 1.24d per 100 cu. m. But modern plant reduces the cost to 10d. per kilogram; and with salt at 1d. per 10 lb. and electrical energy at 1d. per B.t.u., the cost of sterilizing sewage effluent would now be 0.83d. per 100 cu. m, or 0.038d. per 1000 gal. Taking the figure of 0.055 franc, given in the author's paper, for 1 B.t.u., the total cost would be 0.027d. for electrolytic hypochlorite against 0.333d. for ozone.

Speaking as a water-works engineer, he attributed the slowness with which sterilizing processes are being taken up in England to the dislike entertained by the old type of engineer to any patented process. As the author had pointed out, assuming sterilizing to be practicable in England as in Paris, an enormous saving might be effected in London water supply by reason of storage reservoirs not being required and the higher rate of filtration permissible.

Dr. Rideal, in replying, said the process could be looked after by laborers and admitted of testing being carried out easily. He would try to obtain further information as to cost. London water would probably require considerably less ozone than Paris water, owing to the smaller amount of organic matter. It might be possible to replace filtration by the ozone process.

The figures of French chemists cannot be compared with English results on account of the different methods used. He agreed with Mr. Shenton as to the lower cost of hypochlorite.



With regard to the chairman's observations as to expenditure, what would be the cost of the new storage reservoirs? Would it be less than £90,000 per annum, including interest on capital charges?

Professor Whitaker remarked that London was not to be compared with any other place either in this world—or the next.

#### The Standardization of Firebrick and Refractory Materials.

On Jan. 4 a meeting of representatives of several technical institutions constituting the "Committee for Standardization of Refractory Materials" was held at Stoke-on-Trent under the presidency of Mr. J. E. Stead, F.R.S. The adoption was recommended of a preliminary scheme to include (a) the classification of refractory materials; (b) the drawing up of standard specifications for raw materials and finished products; (c) the consideration of making arrangements for uniformity in certain stock or standard sizes, and (d) the standardization of testing and analytical methods.

The representatives of the various societies agreed to acquire all possible information in connection with their especial requirements and particulars of furnace temperatures and working conditions. Each section will work independently, and will report to the next meeting of the general committee, which will finally publish a general report, to be revised periodically and kept up to date. The groups of sections are entitled, respectively: Industrial Sections, Ceramic Society Section, and Manufacturers' Sections. The first includes the chemical and electrical, the metallurgical, the gas engineers', the pottery, and the glass sections. These will deal with (1) materials at present in use, any general information as to analyses, etc.; (2) conditions of use, nature of furnace operations, temperature, and whether the temperature is continuous or intermittent; (3) criticism of materials at present in use; (4) suggestions as to improvement, both in material and in sizes and pattern available.

The Ceramic Section will give attention to (1) definition of refractoriness; (2) grades of materials, based on (a) refractoriness; (b) class of material—aluminous, as clay and bauxite; silicons, as ganister and silica; special, as magnesite, etc.; (3) examination of raw materials; general, as to presence of calcium carbonate, coal, pyrites, etc.; chemical analysis, standard methods; refractoriness, methods of determining; mechanical analysis, methods, etc.; behavior at various temperatures, shrinkage, porosity, plasticity.

The manufacturers will formulate suggestions as to the elimination of odd and little used sizes and shapes; standard sizes and shapes; deviation from specified dimensions in special sizes; the grading of clays, as proposed by the English Ceramic Society, and general suggestions.

LONDON, January, 1909.

## ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

### Electric Furnaces.

**Titanium-Silicon Alloy.**—Mr. Fred. M. Becket, chief metallurgist of the Electro Metallurgical Co., notes the fact that the reduction of titanium ore or of a mixture of titanium and iron ores by means of carbon yields a product high in carbon. The proportion of carbon amounts in the case of titanium carbide to 20 per cent by weight. This is a serious disadvantage in the steel industry. Mr. Becket has found that if silicon is alloyed with the titanium it is possible to reduce the carbon to reasonable limits, say, below 10 per cent. A charge containing 38 per cent rutile, 22 ferrosilicon (50 per cent grade), 20 scrap iron, 20 carbon, yielded an alloy containing 44 per cent iron, 34 per cent titanium, 14 per cent silicon, 8 carbon and traces of aluminium and calcium. The higher the percentages of titanium in the alloy, the more silicon must be added in

order to hold the content of carbon down. (910,894, Jan. 26.)

**Furnace Design.**—Mr. J. H. Reid patents details of polyphase furnace construction. The first claim refers to "the combination with a source of polyphase current of an electric furnace having a crucible formed therein by a plurality of converging electrodes having different phases of the polyphase current flowing through each and an electrode adapted to extend into the top of the charge supported on said electrodes and being connected to the neutral point of the polyphase system." (910,582, Jan. 26.)

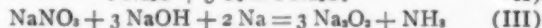
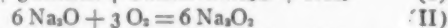
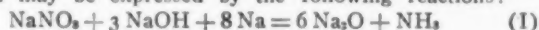
The furnace is intended as a combined arc and resistance furnace, since besides "the arc-producing electrodes" it contains "a plurality of resistance elements, similar in form to the electrodes, all the resistance elements and the electrodes converging to a single point within the furnace, whereby a crucible will be formed on which the charge will be retained until it is reduced and brought to molten state, when the molten elements may drop between the resistance elements and the electrodes." (910,581, Jan. 26.)

### Electrolytic Processes.

#### Manufacture of Sodium Peroxide and Sodium Cyanide.—

Two of the chief uses of metallic sodium (made electrolytically by the Castner process) are the manufacture of sodium peroxide and of sodium cyanide. Mr. C. F. Carrier, Jr., calls attention to the fact that the whole sodium recovered as peroxide or cyanide enters into the usual processes as metallic sodium; the reaction is in the fast case  $\text{Na} + 2\text{O} = \text{Na}_2\text{O}_2$ , and the reaction of a certain cyanide process now in use is given by two equations  $\text{NH}_3 + \text{Na} = \text{NaNH}_2 + \text{H}$  and  $\text{NaNH}_2 + \text{C} = \text{NaCN} + \text{H}_2$ . To reduce the amount of metallic sodium used as starting material, Mr. Carrier uses "a fused bath containing sodium salts, which will be decomposed by sodium, or sodium alloy, in such a manner as to render the combined sodium of the bath available as a source of sodium atoms for the end product; and add sodium, or sodium alloy, to this fused bath." This general principle may be made clearer by application in the two cases above cited.

If sodium be added to a mixed fusion of sodium hydroxide and sodium nitrate in the proper proportions, namely, approximately two parts by weight of the latter to three parts of the former, there are numerous possible reactions, the final state of which may be expressed by the following reactions:



Reactions I and III take place at the same time, the preponderance of either reaction depending upon the condition of the operation and the law of mass action. The actual amount of sodium peroxide produced will, therefore, lie between the results of reaction I + II and reaction III. This same principle may be applied to the production of sodium cyanide. If metallic sodium be added to a fused bath of NaOH in which carbon is suspended and  $\text{NH}_3$  gas be bubbled through the melted mass at the same time, the following reaction takes place:



Instead of employing pure metallic sodium, Carrier finds it advantageous to use lead-sodium alloy, as it may be produced easily by electrolysis of fused sodium chloride with a fused lead cathode (the old Acker process). But the simple addition of lead-sodium alloy in place of sodium to such a bath as specified above for making oxides of sodium is not practicable because lead would be oxidized as well as sodium and the sodium oxide would be contaminated with sodium plumbate. Likewise the alloy could not be used in the formation of sodium cyanide because the alloy produced in practice has not sufficient reducing power to give the desired result.

The author uses a double compartment cell, like that employed in the Ashcroft process, connection between the two compartments being made by fused lead. The "anode com-



partment" contains fused sodium chloride so that sodium is deposited onto and alloyed with the fused lead cathode. The sodium-lead alloy is anode in the "cathode compartment" filled with fused sodium hydroxide. By using an iron or nickel cathode in this compartment, sodium would enter into the fused bath from the fused lead alloy and metallic sodium would be deposited onto the cathode. That would be the Ashcroft process. The feature of Carrier's process is that if  $\text{NaNO}_3$  is added, at intervals in amount proportional to the number of amperes used, the sodium of the lead-sodium alloy will be consumed as fast as liberated according to the following reaction:



The relative values of the factors  $a$ ,  $b$ ,  $c$  and  $x$ ,  $y$ ,  $z$ , will depend upon the condition of the operation. This mixture of  $\text{Na}_2\text{O} + \text{Na}_2\text{O}_2$  can be entirely converted into  $\text{Na}_2\text{O}_2$  by solidifying, pulverizing and heating the powder to over  $300^\circ\text{C}$ . in air free from  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . The lead-sodium alloy, which has been partly depleted of its sodium, is continuously returned to the first compartment.

The production of cyanide of sodium is conducted in the same way, except that a different electrolyte must be used in the second compartment. In this case the fused  $\text{NaOH}$  holds carbon in suspension. The bath is electrolyzed as before and ammonia gas is bubbled through the electrolyte in place of the  $\text{NaNO}_3$  used when sodium oxide was desired. The value of the process, if commercially successful, lies in the production of more of the final product than could be produced from the actual quantity of the metal entering into the reaction as metal or alloy only. (910,498, Jan. 26, 1909.)

**Caustic Soda and Chlorine for Treatment of Fibre.**—By electrolysis of brine, caustic soda and chlorine are produced, both of which are used for the treatment of cellulose fiber, the caustic for separating the fiber from the wood and the chlorine for bleaching. The chlorine gas must be combined with lime to form "bleach" before it is applied to the fiber. The caustic soda effluent from diaphragm cells generally consists of about equal parts of caustic soda and undecomposed salt. The sodium chloride must be separated from the caustic before the latter is applied to the fiber. Messrs. W. V. Wentworth and A. B. Larchar, of the Penobscot Chemical Fiber Co., proceed as follows (Mr. Larchar being the inventor of a diaphragm process which has been described before in this journal): The mixture of caustic soda and sodium chloride is supplied to an evaporator, where it is concentrated, part of the salt crystallizing. The salt crystals with entrained caustic soda are supplied into a vacuum receiver, while in a viscous condition, and are then blown by compressed air into a filter tank, where they are allowed to cool to deposit more salt crystals. Then a valve is opened and the concentrated caustic soda is allowed to filter through simply by gravity and is collected and ready to be applied to the fiber. After several washing operations, the salt crystals are dissolved in hot water and returned with fresh salt to the electrolyzing tanks. The chlorine is passed through a series of absorption towers, where it meets descending streams of milk of lime and forms chloride of lime. The whole apparatus is so arranged that the electrolyzing cells, the concentrator, and the absorption towers are in continuous operation and yield a continuous supply of both bleach and caustic soda. (Apparatus patent 912,339, Feb. 16; process patent 912,340, Feb. 16.)

**Electrolytic Refining of Precious Metals.**—An apparatus, specially adapted for the refining of precious metals, is patented by Mr. Henri Lacroix. It is described in detail and illustrated in an article of the inventor elsewhere in our present issue. (912,859, Feb. 16.)

**White Lead.**—Mr. E. D. Chaplin makes white lead by the following electrolytic process, using a three-compartment cell formed by two porous diaphragms. Sodium nitrate is introduced into the middle compartment; one outer compartment contains a lead anode, the other a copper cathode. Lead nitrate

is formed in the anode compartment and sodium hydroxide in the cathode compartment. "For the purpose of preventing the anolyte from becoming unduly alkaline, because of the liberation of nitrous oxide during the decomposition of the nitric acid in the anode compartment, or from any other cause, and for preventing the resulting formation of insoluble lead salts," nitric acid is added to the anode compartment. (This is made electrolytically in a separate cell from sodium nitrate with a carbon anode.) The lead nitrate and the sodium hydroxide are withdrawn into separate vats. The hydroxide is changed into sodium carbonate by carbon dioxide. The lead nitrate and sodium carbonate are then mixed in a separate precipitating tank; lead carbonate settles on a filter, while the filtrate, which is substantially the original electrolyte, is pumped back into the supply tank. (906,102, Dec. 8, 1908.)

A second patent of the same inventor relates to the manufacture of white lead (or lead chromate, etc.) from crude lead bullion or lead ore, carrying silver, copper, etc. The crude bullion is cast into anode plates. The electrolyzing cell is the same as above. But the electrolyte is a mixture of sodium nitrate and sodium chloride or sodium chlorate (the latter two being added to prevent the formation of insoluble basic salts of lead in the electrolyzer). Sodium hydroxide is again formed in the cathode compartment, while a mixed solution of soluble acid salts of lead, silver, copper, etc., is formed in the anode compartment. This is withdrawn; the silver is precipitated by means of copper in form of copper scrap or ingots, etc.; the solution is again withdrawn and the copper is precipitated by means of lead. The further treatment is like above. (906,103, Dec. 8, 1908.)

The apparatus for carrying out these processes is patented in patent 906,104, Dec. 8, 1908.

**Electrolytic Detinning of Tin Scrap.**—Mr. Meredith Leitch, who has paid considerable attention to electrolytic detinning during the past few years, has taken out two more patents relating to this subject. The first refers to the method of heating and circulating the caustic soda solution. The solution is withdrawn by means of a pump from the detinning bath at a point near the bottom, where it is coolest, is forced through a boiler, where it is heated, and returned to the detinning bath at a point near the top, but below the surface of the electrolyte. The advantage over an overflow arrangement is that with this method of circulation the caustic soda does not come in contact with air, which would result in formation of carbonate. (907,061, Dec. 15, 1908.)

A second patent of Mr. Leitch describes a modification of his apparatus illustrated in our Vol. V, p. 103. There is again a U-shaped basket with perforated walls, having in its interior a conveyor chain carrying tin scrap through the cell. On both sides of the basket are cathode plates. The whole is contained in a tank filled with electrolyte. According to the present invention, the tank is lowered at certain intervals, the electrolyte run off, the tin powder removed from the cathode plates by scrapers and the apparatus is cleaned. (906,726, Dec. 15, 1908.)

**Electroplating.**—For plating a large quantity of small articles, revolving drums, containing these articles, are widely used, as a good circulation of the plating solution is automatically obtained and the articles tumble continually above each other and present in succession all their surfaces to the plating solution so as to get a good all-around deposit. Much of the success of such apparatus depends, of course, on the mechanical construction. Mr. Clarence J. Backus has patented the following design (assigned to Zucker & Levett & Loeb Co., of New York): A rectangular wooden tank contains the electrolyte and within it is placed the revolving cylinder of wood. This has solid circular end plates, the peripheries of which are connected by a series of longitudinal wooden strips. The sides of these strips, of course, taper toward the axis of the drum so as to fit together, and they are provided with a series of grooves which are staggered on the adjacent strips and form

openings through which the plating solution enters into the interior of the drum while it revolves. A portion of the wall of the drum is removable for the purpose of inserting the articles to be plated or for withdrawing them. The cathodes which make contact with the articles to be plated are knobs or balls suspended from the axle of the cylinder so as to be always slightly above the lower surface of the cylinder and to make continually contact with the articles to be plated. The anodes are curved bars surrounding the cylinder from the outside. (908,439, Jan. 5, 1909.)

A patent of Mr. John T. Daniels (assigned to the Hanson & Van Winkle Co., of Newark, N. J.) relates to the material from which the sides or walls of revolving electroplating drums are made. The drum is made of a wooden frame to which are secured sheets or panes of celluloid or xylonite, or "of other mixture of nitro-cellulose with other material, resulting in a non-fibrous, homogeneous substance capable of being readily drilled or punched, free from sulphur or other vulcanizing ingredients, and insoluble in, and unaffected by electrolytes used for electroplating." The sheets are provided with a very large number of minute perforations. Celluloid, etc., is stated to have very decided advantages for this purpose. (911,578, Feb. 9, 1909.)

**Miscellaneous.**—An electrolytic sterilizer for liquid food products is patented by M. R. Frei (907,140, Dec. 22, 1908); an electrolytic apparatus for the purification and sterilization of water, using a series of different metals (iron, zinc, aluminum, manganese dioxide, copper) as electrodes is patented by D. L. V. Browne (910,495, Jan. 26, 1909); a process of separating cream from milk by "passing a series of electric impulses through the milk," by R. W. Padden (907,637, Dec. 22, 1908).

#### Treatment of Gases.

**Chlorine.**—Mr. E. C. Paramore claims to be able to purify chlorine gas and relieve it of its objectionable odor, without detracting from its bleaching quantities, by the following process: The raw chlorine gas is washed with acid to remove moisture and impurities, then cooled in a special refrigerating apparatus, then heated to a high temperature to prepare it for electrification, then passed into a "compound magnetic dielectric device," having "a glass chamber through the walls of which both an electrostatic and magnetic induction influence are caused to pass in such a manner as to effect an increased chemical activity of the gas and deodorization thereof, presumable by its full or partial ionization." The purified gas is finally passed through a second refrigerating condenser of lower temperature than the first for the purpose of liquefying it. (908,126, Dec. 29, 1908.)

## SYNOPSIS OF PERIODICAL LITERATURE.

### Iron and Steel.

**Power Consumed in Rolling.**—Director H. Ortmann, in Völklingen, delivered a report of the work of the German commission upon this subject, in a lecture before the Verein Deutscher Eisenhüttenleute, on Dec. 6. The report is abridged in twenty-eight large pages in *Stahl und Eisen* for Jan. 6, and is of importance to every metallurgist concerned with the rolling of metals because the methods of investigation and the general formulæ found are applicable to rolling in general. The full report will have to appear as a separate publication. The machinery used was equipped with motor drive and with all necessary electrical instruments for determining the power exerted and consumed. The temperature of the steel at each pass was taken by a Wanner pyrometer. The results are expressed as the volume of material expelled from the original length, per unit of energy employed. That is, letting  $S$  be the original section,  $S'$  the reduced section,  $L$  the original length, and  $E$  the energy consumed in the operation, then

$$\frac{(S - S') L}{E}$$

is used as the expression for the extended volume per unit of energy employed. Diagrams are given using this quantity as ordinate and temperature as abscissæ. Chemical analyses, mechanical properties and shapes of the section tested are given. Using lengths in millimeters and energy consumed in meter-kilograms, the tests showed, in rolling different forms, at different temperatures, the following general values for the member of cubic millimeters of steel displaced per kilogrammeter of energy consumed, at different temperatures:

Square ingots to	1300° C.	1200° C.	1000° C.	900° C.
Flat rectangles .....	100	45	20	18
Round .....	80	50	..	..
T-girder .....	85	60	20	10
Rail .....	..	70	20	..

The thorough study of the article is recommended to all interested in the scientific study of rolling metals.

**Blast-Furnace Slags.**—The November 22 issue of *Metallurgie* contains a long article on the constitution of blast-furnace slags by M. Theusner, of the Berlin Technical School. We are obliged to omit the reproduction of very elaborate lithographed chart. The paper opens with a discussion of previous work along this line, some of the investigations on the constitution of Portland cement also being noted. For the study proper four blast-furnace slags of the following localities and compositions were taken:

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	MgO	FeO	MnO	S	P <sub>2</sub> O <sub>5</sub>
Bochum:								
Slowly cooled.....	29.47	13.96	45.65	6.2	0.77	0.48	2.89	...
Chilled .....	29.68	13.84	45.48	6.29	0.68	0.54	2.72	...
Kneutlingen:								
Slowly cooled.....	31.20	17.36	44.00	3.74	0.58	1.32	1.42	...
Chilled .....	31.30	17.65	43.70	3.60	0.49	1.36	1.38	...
Neunkirchen:								
Slowly cooled.....	30.75	18.10	42.88	3.78	1.20	1.64	1.82	0.02
Chilled .....	30.83	18.18	42.73	3.74	1.18	1.58	1.63	0.02
Kratzwick:								
Slowly cooled.....	25.63	14.90	51.21	3.64	0.60	0.20	4.13	0.02
Chilled .....	25.71	15.02	51.03	3.53	0.57	0.25	4.00	0.02

The chilled slag was made by granulating in water. Three solutions were used in the investigation: (1) a 2 per cent solution of citric acid; (2) a solution of ammonium citrate made by adding to 10 liters of water 1500 grams of citric acid and 3594 cc of ammonia, specific gravity, 0.967; (3) a saturated solution of ammonium chloride; 5 grams of finely ground slag were used in each test. The chilled slag settled in the solution more rapidly than the slowly cooled, and was in general more quickly attacked than the slowly-cooled slag. The more lime in the slags the easier the attack. Alumina plays the part of a neutral material. Complete tables are given of the amount dissolved from the various slags by the three solutions in two, five and eight hours, the composition of the residue and the composition of the dissolved portion. In general, the more basic the slag the greater the decomposition. In the basic slags a large portion of the lime goes into solution, the proportion of silica to alumina remaining quite constant in the residue. In the less basic slag a proportionately larger amount of lime remained in the residue. The change in the various slags is well shown in a tri-axial diagram. Microscopic examination of the slags showed in the Neuenkirchen slag rectangular crystalline aggregates which were determined to be mellilite. The Kneutlingen slag showed the same, but not so prominently. A slag of the composition of mellilite was made up and subjected to the action of the three solutions used in the original investigation with an identical result. Mixtures were made up consisting of all possible combinations of 60, 10 and 30 parts of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub> and CaO and treated with the three solutions and examined microscopically, the results given in photographs and tables, but no conclusions drawn therefrom.

**Cupola Practice.**—Th. Ehrhardt, of Halensee, Berlin, describes in *Stahl und Eisen* of Jan. 13 some recent improvements in cupola practice. The principal are the automatic charging apparatus, spark catchers outside the roof and fore-hearths



adapted for continuous overflow of slag, and intermittent tapping out of the iron.

**Cupola Economy.**—Dr. C. Geiger, of Dusseldorf, has made careful cupola experiments using

Dry coke with 0.5 to 0.8 per cent of water.

Moist coke with 5 to 8 per cent of water.

Wet coke with 10 to 18 per cent of water.

The cupola had a fore-hearth 0.9 m in diameter by 1.05 m deep, and melted 3.5 tons per hour. Careful analyses were made of the cupola gases and all weights of fuel and iron recorded. The results showed the water to keep the top of the cupola cooler, to decrease the percentage of CO in the gases and increase that of CO<sub>2</sub>, while in consequence the total fuel used (dry weight) was diminished. The figures are as follows:

	Water.	CO <sub>2</sub> .	Carbon used per	
			CO.	100 kg. iron.
Dry coke .....	0.5	13.3	10.7	6.89
Moist coke .....	6.5	16.0	7.2	6.58
Wet coke ..	10.0	17.7	5.0	5.95
Very wet coke .....	18.0	17.3	6.0	5.59

The reason for the economy is hinted at in the article, but not very clearly set forth. It is undoubtedly due to the fact that when a kilogram of dry coke goes into the cupola it soon becomes heated and commences to reduce CO<sub>2</sub> to CO. If, however, it carries with it 0.22 kg of water (as in the very wet coke), this absorbs, in being evaporated, at least 150 calories, thus taking heat which the carbon would otherwise, in great part, absorb. Such 150 calories would raise the kilogram of coke 300° C. or 400° C. The coke is thus kept cool for a considerable time and to a considerable depth in the cupola, the time during which it can reduce CO<sub>2</sub> to CO is correspondingly shortened, and the resulting increase of CO<sub>2</sub> in the gases is explained. This, of course, means a corresponding better utilization of the fuel.

**Low-Grade Iron Ores.**—An entirely new scheme for the treatment of low-grade iron ores appeared recently in *Iron Trade Review*. It is called the "step process," and consists in passing the finely ground ore through a revolving cylindrical furnace at the same time reducing the oxide of iron to metal by means of a current of gas rich in hydrocarbons. All the gangue of the ore remains unreduced and intimately mixed with the metal. It is removed later by a squeezer or balling mill. The product is to be used in place of steel scrap in open-hearth practice. The process can be applied to very low-grade ores at a cost of less than \$1.50 per ton of material treated.

**Melting Point of Iron.**—It comes somewhat as a surprise to most of us to find that we have been using a figure some 100 deg. too high for the melting point of pure iron, but such seems to be the case from the figures given by H. Carpenter in *Metallurgie*, Nov. 22. He gives as the melting point of pure iron 1505° as measured by Le Chatelier pyrometer and 1491° to 1519° for optical scale. The freezing point is independent of the gas in contact with the metal, a fact difficult to explain when we know that oxide of iron is quite readily dissolved by the molten iron.

#### Tin.

**The History of Tinning.**—Otto Vogel, of Dusseldorf, in a lecture before the "Deutscher Giessereifachleute," Dec. 5 (reprinted in *Stahl und Eisen*, Jan. 13), relates some interesting history. Although the invention of tinning is generally credited to the Gauls, on the authority of Pliny, yet the author has unearthed a paragraph of Theophrastus, who lived and wrote 300 B. C., which says: "It is related of the Athenians that they dip red-hot clean iron into earthen pots containing tin. This operation does not alter the weight, but is done to avoid the taste which the iron articles otherwise impart to the food." Pliny said, several hundred years later: "The tinning of copper cooking utensils gives the food a better taste and protects from the poisonous verdigris, and without making the

vessels heavier." This statement about the weight not being changed apparently passed current for centuries, until Beckmann, in 1797, weighed carefully a copper vessel before and after tinning, and found that it had really gained 2 per cent in weight. The history of the legislation against the use of lead in the tin, in lining cooking utensils, beginning at Berlin, in 1768, is curious and interesting.

#### Fuels.

**Moisture in Coke.**—Experiments are described in *Stahl und Eisen* of Jan. 6, on the amount of water which red-hot coke can absorb when quenched in cold water, which led to "the surprising result" that three to four times as much water is thus taken up as is absorbed by the same coke when dipped cold into hot water. It appears to us that a little reflection will remove the cause of the surprise. Coke possesses pores which remain filled with air even when dipped into water. For a rise of temperature the gases contained in said pores diminish in density, such that at a bright red-heat (800° C.) the real quantity of gas present in the pores is only one-quarter what it would be if the coke were cold. Quenching the bright red-hot coke, therefore, imprisons in the pores only one-fourth the quantity of air or gas, and allows, therefore, three or four times as much water to get into the pores as when the coke is first cooled and then dipped into warm water.

#### Miscellaneous.

**Manganese Bronze.**—J. L. Jones, in *Metal Industry* for January presents a time criticism of the government specifications for manganese bronze. The figures given for elongation and for contraction of area should be made very much more nearly equal. The specifying of an elastic limit without the details as to how it is to be determined is quite meaningless when the effect of the method of test on the figures obtained is considered. The author also criticizes the clause calling for a foundry test on the part of the government, claiming that the ignorance of the government molder as to the handling of the particular alloy submitted might lead to the condemning of an otherwise satisfactory alloy.

**Antimony.**—With the increase in the demand for antimony in the alloy and pigment industries there has appeared several articles on the metallurgy and treatment of this metal. The most recent one appeared in *Revue de Chimie Industrielle* for October by the French metallurgist, Pautrat. The older method of liquating the stibnite ores and precipitating the liquated sulphide by iron is fast disappearing. The more modern method is to charge the ore with fuel in a furnace similar to a lime kiln and urge the fire with a large excess of air. The antimony sulphide liquates out, is oxidized and the oxide condensed in suitable chambers and flues in combination with the furnace. The purity of the condensed oxide varies greatly in the different chambers of the condensers, though it is not uncommon to obtain a product carrying 98 to 99 per cent oxide. Arsenic oxide is the greatest impurity. For reduction to metal this oxide is briquetted and charged into a reverberatory furnace with coke and carbonate of soda in the proportions of 700 oxide, 70 soda and 80 carbon. A scheme for analysis of arsenic and antimony oxides concludes the paper.

**Silicon as Reducing Agent.**—Paul Askenasy communicates to *Zeit. f. Elektrochemie*, Dec. 11, some interesting facts regarding the use of silicon for reduction and fusion of various materials. When barium peroxide and fine silicon powder are mixed together and the mass ignited, the reaction is usually so violent that the mass is blown out of the containing crucible. The author has found that by using a coarser barium peroxide the reaction can be completely controlled. A barium silicide was made by mixing 50 parts of barium peroxide and 15 parts of powdered 90 per cent silicon and igniting. The silicide contained about 30 per cent barium. It is quite brittle and decomposes water with evolution of hydrogen, and hydrochloric acid evolves silicon hydride from it. On mixing 2 kg of barium peroxide, 80 grams of sodium peroxide and 1.4 kg



of iron filings and igniting, the iron was melted and run out the bottom of the crucible similar to thermit iron. The silicon did not alloy with the iron and the reaction is not so violent with dry materials as to expel the mass from the crucible. Copper can be fused and raised to the same high temperature in the same manner. It is possible also to reduce several metallic oxides. Very finely pulverized ferrosilicon can be used instead of the silicon for fusing the iron, no silicon entering the latter metal. By mixing titanous acid and silicon a silicide of titanium,  $Ti_2Si_3$ , was obtained, and on using this mixture with the peroxides iron was melted which contained considerable titanium and was very hard.

**Aluminium Carbide.**—Askenasy, in *Zeit. f. Elektrochemie*, Dec. 11, gives some new information of the formation and decomposition of aluminium carbide. Briquettes were made of alumina and wood charcoal in the proportions  $2 Al_2O_3 + 9 C = 6 CO + Al_4C_3$ . They were heated in an electric arc furnace and after removal were found to have been transformed into scaly crystals of black color. On lying in the air for several days the briquettes fell apart, and in the interior were found yellow carbide crystals. On separating these crystals and heating them in a porcelain crucible it was noticed that when the temperature was raised but slightly above the melting point of aluminium this metal sweated out. In general, when the mixture, after heating in the electric furnace, was cooled quickly carbide only was obtained, but when the mass was cooled slowly metal always oozed out of the pieces.

## RECENT METALLURGICAL PATENTS.

### Copper.

**Pyritic Smelting.**—In attempting to smelt by pyritic methods certain classes of copper or copper-nickel ores which are otherwise suitable for the purpose, difficulty is experienced owing to the refractory nature of certain constituents of the ore, among the most important of which are certain coarsely crystalline feldspars. Such material is in a high degree chemically inert and attains no more than a plastic condition at the highest temperature ordinarily attainable in a pyritic furnace, in which condition it is incapable of readily entering upon the chemical changes necessary for its conversion into slag, but, on the contrary, it forms accretions which in a short time choke the furnace. Mr. James Taylor Carrick, of Johannesburg, proposes to overcome this difficulty by producing in the furnace, at the base of the "focus" (the region of active slag formation), a restricted zone of higher temperature than the rest of the furnace. In coming into contact with it, the "infusible" ore constituent becomes liquefied, when it is at once acted upon by the other parts of the charge and thereby reduced to readily fusible slag. Such zone is advisedly as narrow as possible consistently with the total liquefaction of the ore, since any considerable increase in the total heat of the furnace is not aimed at, nor would it be desirable. To produce the specially hot zone a special series of tuyers is provided immediately below the level of the air blasts, and through those tuyers gaseous fuel with air is introduced, producing special flame blasts just sufficiently below the regular air blasts for the combustion of the former to be completed before they mingle with the air blasts. (912,540, Feb. 16.)

### Iron.

**Petroleum for Iron Reduction.**—Mr. Edward D. Kendall proposes to reduce iron oxide ores by means of petroleum or products from petroleum. The ore is first crushed or pulverized, a hard red hematite should preferably be pulverized to pass through a sieve having 40 meshes to the linear inch. This comminuted ore is to be thoroughly mixed with granulated or pulverized lime or limestone, broken or crushed lime or limestone may be added. With this mixture is to be incorporated heavy petroleum, practically non-volatile at the

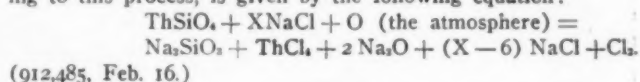
ordinary temperatures, or petroleum residues, liquid, semi-solid or solid, which remain after distilling off the lighter hydrocarbons from the natural petroleum. Granulated or pulverized hematites alone cannot carry in the interstices enough petroleum or petroleum-product (liquid or melted solid) to effect complete reduction of the ore and, therefore, must be associated with the lime or limestone; that is to say, with the slag-forming body or bodies, in order that the mass shall have a sufficient capacity of absorption. The temperature required for reduction is below red heat, so that reduction may be accomplished in suitable well known forms of iron retorts, the melting of the slag-forming bodies and fusion of the reduced iron to be effected afterward in a suitable furnace. (12,918, Feb. 9, 1909.)

### Alloys.

**Bearing Metal.**—A suitable alloy for journal bearing and shaft bearings may be obtained, according to W. G. Black, by the following composition: Copper, 50 to 60 per cent; iron, 40 to 50 per cent; nickel, 4 to 6 per cent; lead, 6 to 15 per cent; aluminium, one-quarter of 1 per cent to one-half of 1 per cent. The main object of incorporating lead into the alloy is to impart a certain degree of softness to the alloy, the quantity of lead that is introduced varying according to the use for which the alloy is intended. The nickel in the alloy is greasy and thus acts as a lubricant. (912,645, Feb. 16, 1909.)

### Thorium.

**Reduction of Thorite.**—To recover thorium from ores Mr. Robert McKnight mixes the comminuted ore with sodium chloride much in excess of the amount required to furnish chlorine for the chloridizable constituents of the ore. The mixture is heated in a revolving cylinder to a temperature which need not exceed  $700^{\circ} C$ . By this treatment the thorium in the ore is converted into a volatile and soluble chloride or double chloride of sodium and thorium. What is volatilized is condensed in a suitable condenser, and the residue, preferably while hot from the furnace, is allowed to fall into water, and thus by the sudden change of the temperature is quickly disintegrated and crumbled and the portion of the thorium which has not volatilized is obtainable in solution, from which its oxide or the metal itself can be obtained in any suitable manner. A limited amount of water is preferable to obtain a supersaturated solution of the thorium, which on standing is precipitated, leaving the more soluble alkaline chloride in solution, from which it can be recovered by spontaneous evaporation or otherwise and used in the treatment of the new ore. The principal reaction in the reduction of thorite ore, according to this process, is given by the following equation:



### Titanium.

**Reduction of Refractory Oxides.**—In the well-known aluminothermic reaction of Goldschmidt aluminium is used as reducing agent for refractory oxides. K. A. Kühne has formerly proposed to use a mixture of aluminium and chlorates or perchlorates instead of pure aluminium, and he now suggests to substitute peroxides for the chlorates or perchlorates. The use of barium peroxide or sodium peroxide is specially referred to. The object of adding this peroxide is to accomplish that "its oxygen may, by increasing the rate of oxidation, raise the temperature so high that even those oxides may be reduced that could not be reduced by the original Goldschmidt process." Care must be taken to produce a slag which is as thinly fluid as possible. For this purpose suitable additions of fluorspar, lime, etc., are to be made. For the reduction of titanium by this process the equation is as follows:



Evidently more aluminium is used in this case than in the aluminothermic reaction, because the aluminium has to absorb the oxygen both from titanium and barium. (910,394, Jan. 19.)

## The Use of Titanium in Steel for Rails, Car Wheels, Etc.

BY CHARLES V. SLOCUM.

I have read with much interest various articles which have appeared in this journal from time to time on the consumption and wear of steel rails, car wheels, etc., with recommendations of the use of the electric furnace for steel refining. In my opinion, a very important factor to be reckoned with in future in all these matters is usually being entirely overlooked. This is the use of titanium in steel.

With the aid of titanium it is possible to make better rails from Bessemer converter steel than is possible without its aid from open-hearth steel. With the aid of titanium it is possible to eliminate blow-holes. It is further possible to remove the brittleness and increase the durability of chilled-iron car wheels; further, to improve nickel steel, chrome and nickel steel, etc.

These are very strong statements, but they are made on the basis of the experience gained in fifteen months' trials in many mills by scientists and by plain mill men.

The element titanium is introduced into the steel in the form of the alloy ferrotitanium. This is made by the electric-furnace process of Mr. Auguste J. Rossi (which has repeatedly been described in this journal) at the works of the Titanium Alloy Manufacturing Co., at Niagara Falls. The sales offices of the company are at 5500 Irwin Avenue, Pittsburgh, Pa. This ferrotitanium is sold under the trade name "titanium alloy." It contains from 10 to 15 per cent titanium, 5 to 7 per cent carbon and less than 0.5 per cent other impurities. The balance, some 80 per cent, is iron.

### Titanium for Bessemer Steel.

Ferrotitanium was used for the first time in a heat of Bessemer steel in this country at the works of the Maryland Steel Co. in November, 1907, under the personal supervision of Mr. Simon S. Martin. The steel made at this first trial showed so

metal at a given point in excess of that of the untreated metal at the same point, while passing through the rolls.

The titanium alloy was added in the ladle after the blow, and after the manganese, the former being simply shoveled in cold by a laborer while the steel was flowing into the ladle.

The Maryland Steel Co. has since the foregoing trials run many heats treated with titanium alloy, with unvarying success. Aluminium was not used, and should not be used in any case, or at any time with titanium alloy.

Experiments on the use of titanium for Bessemer steel have also been made at the Duquesne works of the Carnegie Steel Co., at the Cambria Steel Co.'s works and others.

Very exhaustive trials of titanium alloy have been made at the works of the Lackawanna Steel Co. during 1908, under the direction of an expert from one of the largest railroad lines in America. These tests were markedly successful and the railroad in question now endorses the merits of the alloy for the marked improvement which it gives to Bessemer rails.

Rails treated with titanium alloy and made by the Maryland Steel Co. have been in service for several months on Kesslers Curve on the Cumberland Division of the Baltimore & Ohio Railroad, where the traffic and the grade are both very heavy. Diagrams of these rails have been taken at intervals of two to three weeks, together with diagrams of the plain Bessemer rails put in at the same time and place. The greater durability of the titanium rail is so marked as to be fairly startling. The lower plain rails, although of best quality Bessemer, have flattened or "flowed" considerably, while at this writing the titanium rails have not "flowed" at all. The upper plain rails are cut down practically the full depth of the flange of the wheels, while the upper titanium rails are cut less than half as much.

### Titanium for Open-Hearth Steel.

Titanium alloy has been used by many open-hearth steel works with unvarying improvement to the product. The general characteristics are freedom from blow holes, increase of elastic limit, increased reduction of area, etc.

The increase in quantity of slag removed or "lifted" by the alloy is almost as remarkable in open-hearth steel as in the Bessemer product.

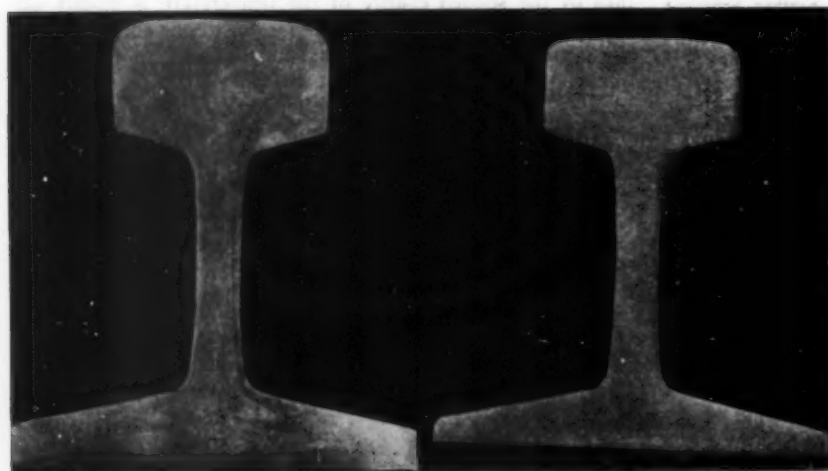
The titanium itself passes off with the slag which it removes, unless unusual quantities of the alloy be added, when the excess above the quantity necessary to remove the impurities remains in the steel.

Rolls made from open-hearth steel treated with titanium alloy are closer grained, absolutely free from blow holes or pin holes, are more durable than any other rolls, and are easily machined.

Open-hearth castings from metal treated with the alloy are more blue in color, are free from blow holes, are free from brittleness, are easily machined, and heat less under the tool, hence may be machined more rapidly than other steels of the same carbon content.

With respect to the removal of blow holes, the well-known high affinity of titanium for oxygen and nitrogen is, of course, of greatest importance. Any oxide of iron is perfectly removed by titanium.

The reaction due to the titanium addition is always accompanied by an evolution of heat which may result in an increase of temperature from 30° to 50° C. In an experiment of Messrs. FitzGerald and Bennie the rise in temperature, according to the Fery radiation pyrometer used, was 30° C., although the titanium caused the formation of slag which cut off the radiation somewhat from the pyrometer. They state that their tests indicate a distinct rise in temperature to be obtained "even



SECTION OF PLAIN BESSEMER STEEL  
RAIL.

SECTION OF TITANIUM-TREATED BESSEMER RAIL.

Photographs taken from steel by Booth, Garrett & Blair, of Philadelphia.

much improvement over ordinary Bessemer that a further shipment of titanium alloy was hurried forward and trials in several heats were made on Dec. 16, 1907.

These trials developed several remarkable features, probably the most important of which was the unprecedented increase in the quantity of slag removed from the steel. The treated metal invariably lay "dead" in the ingot molds. The steel was absolutely free from blow holes. The titanium-treated ingots were noticeably hotter than the untreated ones. An examination of the record from the pyrometer gage for the day's work showed an increase of not less than 15° C. in the heat of the treated



with so small an addition as 0.5 per cent of the 10 per cent titanium alloy."

In view of these facts the amount of ferrosilicon which would be used for the same purpose should be reduced, when ferrotitanium is employed. It is suggested that the silicon be reduced gradually from time to time until no further improvement is noted. If dirt specks are found in the surface or "skin" of the steel the ferromanganese should be slightly increased by adding, say, 10 lb. for each 100 lb. of Mn used, and the ferrosilicon should be cut out.

#### Ferrotitanium for Crucible Steel.

As said before, the use of titanium improves Bessemer steel so that it becomes better than present open-hearth steel. It brings open-hearth steel nearer to crucible steel quality. That with the aid of titanium it is possible to improve even electrically refined steel of crucible steel quality is indicated by the following tests quoted from Mr. F. A. J. FitzGerald's recent American Electrochemical Society paper (ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, December, 1908, page 494).

"The following tests were made from bars 1 in. sq. hammered from 6 x 6 bottom cast ingots. The elongation was determined in a length of 2 in.:

Heat No.	Tensile strength.	Elastic limit.	Elongation per cent.	Reduction per cent.
9.....	57,000	34,000	33	58
27.....	77,000	45,000	28	56

The steel of heat No. 27 was treated with 0.1 per cent of titanium."

The analyses given by Mr. FitzGerald are the following for the two heats mentioned above:

Heat No.....	9	27
Carbon ..	0.10	0.22
Manganese ..	0.75	0.94
Phosphorus ..	0.015	0.033
Sulphur ..	0.070	0.056
Silicon ..	0.02	0.03

A bar of steel 4 ft. long,  $1\frac{1}{8}$  in. square made from this titanium steel (heat No. 27) was subjected to cold twisting

TITANIUM STEEL (HEAT 27),  $1\frac{1}{8}$  IN. X  $1\frac{1}{8}$  IN. X 4 FT., TWISTED COLD. SEVEN COMPLETE REVOLUTIONS.

test, seven complete turns or revolutions without a fracture. The accompanying illustration is reproduced from a photograph direct from the steel.

It has been found by experiment many times repeated that titanium alloy increases the strength of nickel and chrome-nickel steel. It is a well-known fact that when nickel is added to steel an important percentage of oxide of nickel is formed. Titanium alloy used afterward thoroughly deoxidizes the metal.

The alloy also "removes nitrogen in the proportion of about four parts titanium to one of nitrogen, a very important fact since neither chrome, nickel, molybdenum nor tungsten combines with nitrogen, so that none of these metals nor their ferros can be used for removing this gas to form with it a stable combination to pass into the slag." (A. J. Rossi.) Hence the following statement of Prof. Le Chatellier, of Paris, is very pertinent:

"The treatment of all steels with ferrotitanium for the purpose of the purification of the metal is strongly recommended. The presence of nitrogen to the extent of 0.02 to 0.045 or 0.035 in certain steels being enough to cause the metal to break asunder, destroying all elongation and reduction of area." (Congress of Metallurgists, Belgium, 1905.)

To sum up, the effect of titanium alloy in steel is to remove the oxides and nitrides to increase the fluidity and temperature of the metal and to increase the quantity of slag which it not only removes, but with which the titanium itself passes off.

The resulting product is stronger, more durable and more easily machined. The casting heats less under the tool and gives greater resistance to shock strain or wear. Titanium alloy has been used with success in gears, pinions, automobile cylinders, dies and die blocks, chilled rolls, car wheels, acid pots, etc.

#### Ferrotitanium for Chilled Castings.

Tests made by Prof. M. Hokanson at the Carnegie Technical Schools of Pittsburgh demonstrate that the crushing strength of chilled iron is increased nearly 100 per cent by the use of 1 per cent of titanium alloy. Prof. Bradley Stoughton, of Columbia University, recently placed this increase in strength for gray-iron castings at 20 to 40 per cent. (Metallurgy of Iron and Steel, by Stoughton.)

Tests by the Brinell method show that chilled iron treated with titanium is harder than the untreated metal, although the chill is reduced by the alloy, and yet gray iron back of the chill is readily machined, such as hubs of car wheels, etc.

A number of tests of car wheels treated with titanium alloy are in progress on several different roads, both steam and electric.

In dies and die blocks the alloy gives tremendous resistance to shock and consequent large increase in life of such castings. The Midvale Steel Co. state they have adopted the alloy as standard in these castings.

A demonstration of the value of titanium alloy in iron was made at the car-wheel foundry of the Norfolk & Western Railway Company, at Roanoke, in August, 1908. One per cent of the titanium alloy was used in the charges and passed through the cupola without any other handling whatever.

Sixty wheels were poured from the metal treated with alloy in this manner, 15 test bars 2 in. x 2 in. x 24 in. were made during this period, then after all the treated metal had been poured off, 60 other wheels were poured and 15 more bars were taken from the plain metal.

After annealing, these bars were all broken on supports 21  $\frac{1}{3}$  in. apart. Two bars were imperfect and the comparative results of the other 26 are given below in deflection, the breaking strains not having been furnished:

Treated metal.	Plain metal.
0.075	0.070
0.120	0.090
0.230	0.190
0.325	0.180
0.085	0.075
0.160	0.125
0.080	0.075
0.085	0.090
0.215	0.180
0.360	0.315
0.080	0.075
0.065	0.065
0.350	0.265
2.230	1.795

From the above it will be noted that this strong car-wheel iron treated with titanium alloy gave 24.4 per cent more deflection under stress than the plain metal, which is one of the best possible indications that the alloy removes brittleness and makes car-wheel iron more like wrought iron; an absolute preventive of chipped flanges, broken rims, shell outs, cracked plates, etc.

The sample wheels passed the drop and thermal tests with a wide margin of safety above both the M. C. B. and B. & O. specifications.

The alloy reduces the chill somewhat, but this is readily overcome by regulating the mixture correspondingly.

Titanium alloy may be used in iron in several different ways, viz.: in the furnace or cupola, in spout or ladle, and in the crucible.

By the first two methods it is merely necessary to add the

alloy to the charge or charges without further attention.

When a reservoir ladle of iron is to be treated, the alloy is fed into the spout while filling first half or two-thirds of ladle. It is useless to add it later as it then unites with the slag and could have no effect on the iron. It should not be added in

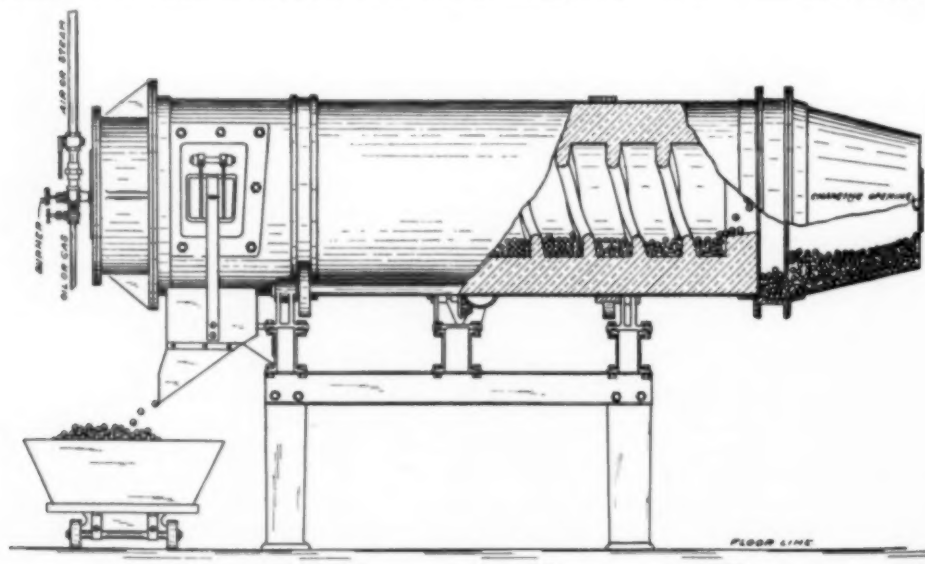


FIG. 1.—DIAGRAM OF THE HELICAL FURNACE.

spout if the stream must pass through slag. The object of the alloy is to remove the slag still remaining in the iron. It is obvious that if the alloy unites with the surface slag it remains there and cannot later improve or even affect the iron.

In treating iron in smaller ladles for 100 to 500 pounds of molten metal, the alloy should be fed into the stream while filling the first half of the ladle, so that the alloy will receive much churning and swirling, the whole should be stirred vigorously for a moment with an iron rod (not with wood) and then pouring begins. The pouring need not be hurried, as the metal will be hotter and more fluid than usual in ordinary foundry practice.

The percentage of alloy to be used varies with the grade of iron to be treated and the results desired. Ordinarily 1/10 per cent titanium is found to be a very good proportion, i. e., 1 lb. of the 10 per cent alloy to 100 lb. of iron.

In the crucible half of this percentage will have great effect.

As was mentioned on page 88 of the February issue of *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY* a special titanium alloy, "cupro-titanium," is made for use in the copper and brass industry. The use of this alloy ensures freedom from blow holes and permits the production of solid copper castings.

The Denver Fire Clay Co. have sent us their illustrated bulletins on the Case laboratory crusher, Case melting furnaces (for gasoline, gas or oil firing), muffle furnaces (for coal, wood, coke and oil firing), and metallurgical clay goods.

### The Internally Fired Helical Furnace.

Ry C. M. RIPLEY.

Uniformity of heating of material in manufacture, if heating at all is necessary, is probably the most important operation to which the material is subjected, and has more influence to make or lose money for the manufacturer than any other. The good or ill effects of annealing or hardening extend to all future operations upon the metal and to the very life of the material itself.

Every practical manufacturer who handles material which requires annealing or hardening to fit it for use, knows that it is best and commands the highest price when it has been properly and uniformly heated. Yet he does not always realize how easily his furnace or his fuel may defeat his best efforts; or, on the other hand, how easily these two things, if right, may help him to complete success. I say help because while the furnace and fuel are fundamental, they are not all

that is necessary. His employees must be carefully instructed and they must know that the heat treatment is right all the time.

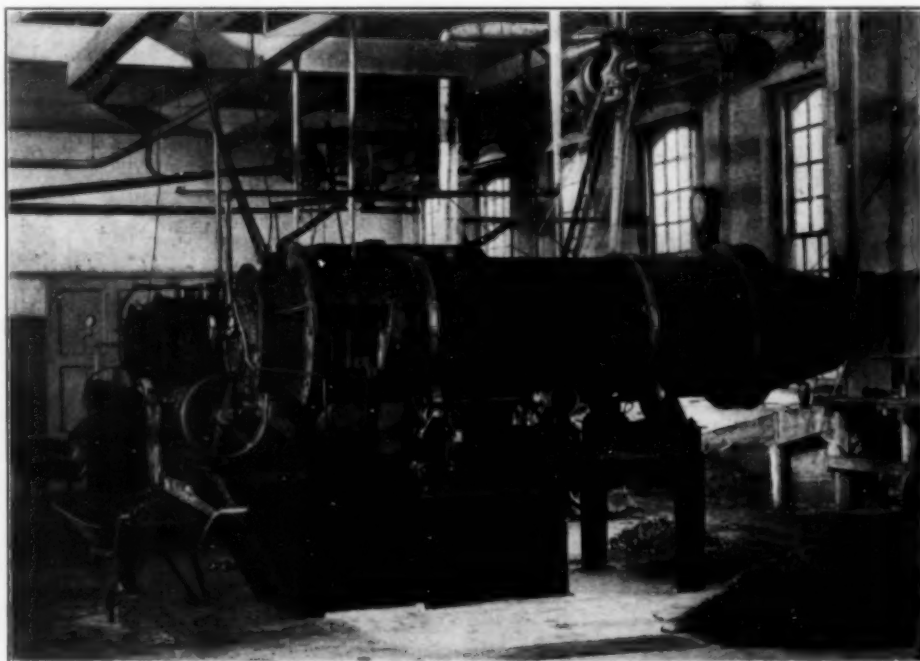


FIG. 2.—INTERNALLY FIRED HELICAL FURNACE.

Take Mr. Edison's cement furnaces for example—ten of them, 150 feet long, 9 feet internal diameter—at his cement works, New Village, N. J. Cement men said he could not successfully operate furnaces that long. Possibly he could not with their fuel and their methods. But he could and does with *his* method and *his* fuel—pulverized coal injected with a jet of compressed air at 80 lbs. pressure. The old furnaces were too short; so he made long ones. The coal was not suitable in its natural condition, so he pulverized it to suit himself. He permitted nothing to stand in his way. He



made the furnaces and fuel do what he wanted them to do—produce 8000 barrels of the first grade of Portland cement every day.

Much annealing and hardening is still done in old-style stationary furnaces, and owing to the size and shape of much of the material it must continue in that way, whatever the inconvenience and expense. Where size and shape have permitted some work has been and is being done in rotating cylinders heated from the exterior. Such cylinders are generally made of cast iron, but when heated externally the life of the iron is too short. Moreover, the heat is not utilized as economically as when directly applied by internal firing. Tumbling barrel furnaces and bucket and chain conveyor furnaces have been used for certain low-temperature work, each kind having its limits as to durability and efficiency.

In this country alone there are thousands and millions of small equal size bits of valuable material in brass, copper, steel,

point of discharge, where a pyrometer is so located as to show exactly what that ultimate heat is. Such heating is the exactly correct method, especially for hardening steel which should enter the bath at its rising hardening temperature. This action is important, also, in preventing or reducing oxidation.

Each piece is exactly right and the day's output is all the same. For example, a lot of 15,732 pieces of steel was run through one of the furnaces here shown and hardened in oil and each piece was then carefully tested. Only two were found imperfect, and they from flaws in the steel itself, not from the heat. The manufacturer stated that such runs were the rule, not the exception. Experience seems to prove that protection from oxidation and saving of time are both effected when the material is heated up gradually, never overheated and discharged the moment it has reached its ultimate temperature.

When the furnace was used for hardening a quenching tank

with a conveyor was provided below the discharge spout so that the material after immersion was automatically removed from the bath quite clean and delivered into a truck or wheelbarrow. Provision was made so that two kinds of material could not become mixed; nor could any lodge in any part of the furnace or bath. By the simple removal of two bolts the conveyor could be easily removed from the bath, giving free access to every part thereof for cleaning or other purposes.

The furnace requires no chimney. A hood to carry off fumes from the oil bath or from machine oil on the material is sometimes desirable.

Either air or dry steam may be used to inject the oil

or gas fuel. Coal or coke fuel cannot be used.

One of the chief features of the internally-fired helical furnace is its durability. Practically all the iron work is out of range of the fire, and all the parts are simple and strong.

The furnace is manufactured by W. S. Rockwell Company, 50 Church street, New York.

### Silicon-Calcium-Aluminium Alloy.

A silicon-calcium-aluminium alloy is being introduced in this country by Messrs. C. W. Leavitt & Co., of New York City, the analysis being approximately silicon 47 to 57 per cent, calcium 15 to 25 per cent, aluminium,  $2\frac{1}{2}$  to  $6\frac{1}{2}$  per cent.

The two chief applications of this alloy are as an energetic deoxidizer and for securing a better desulphurization.

This alloy contains the two elements most useful for the deoxidation of a metal (silicon and aluminium), and also calcium, which is a very energetic reagent. Added into the ladle it calms the steel and enables the tapping of sound ingots. The products of the reaction of this alloy are double silicates of calcium and aluminium, which have a low melting point, the slag rising to the surface of the steel.

This alloy is said to give better results than aluminium alone, even when it is added into the ingot mold itself, because it forms a very easily fusible slag which disengages from the steel.

The alloy may be introduced either into the furnace a short



FIG. 3.—CHARGING OF THE ANNEALING FURNACE.

aluminium, gold, silver, and other metal, which must be annealed or hardened every day, such as cartridge shells, ferules, eyelets, buttons, caps, cups, coin blanks, steel balls, saw teeth, tacks, screws, rivets, rings, springs, nuts, punchings, etc., and it was only natural that the internally-fired helical furnace here described and illustrated should have been designed to heat these pieces in wholesale fashion.

The furnace shown in the adjoining illustrations is formed of a steel cylinder, with a smooth fire-tile lining of helical form and is rotated upon rollers supported by a suitable iron frame. The power may be furnished from a line shaft or from a motor suitably controlled. Ordinarily the speed is from 1 to 3 revolutions per minute and the time of travel through the furnace from 3 to 10 minutes. Either oil or gas may be used as fuel, and it is injected directly into the chamber in the opposite direction to that of the travel of the material.

Combustion is complete, and the spent gases find vent where the material enters—giving up their heat to the incoming material as they pass, in the spirit of true economy. For not only is the heat thus saved, but the material is thereby heated up in that gradual manner which is best for it. The material is charged into the feed-drum in bulk and is then wormed through the furnace at a perfectly uniform and positive speed.

Starting cold the material winds its way through the convolutions of the furnace for a distance of about 47 feet, ever tumbling over itself, ever on a new hot surface, ever in the direct heat, yet only reaching its ultimate heat at the very

time before tapping, or into the tap-hole during the tapping, or even into the ingot mold instead of aluminium or together with aluminium.

### Pyrometry in Relation to Boiler Plants.

By CHAS. E. FOSTER.

The design of a boiler is, like most engineering works, a compromise. Here, as elsewhere, the battle is fought between cheapness on the one hand and efficiency in operation on the other. Allied to the forces working for cheapness is the desire that the boiler, with its accessories, shall occupy small floor space, and generally efficiency suffers rather badly in the encounter.

Frequently we see published the statistics of boiler designs, and among these will be found grate area and heating surface. We are told with great exactness how much room there is to spread the fuel and what is the area of the surface through which the heat from the fuel may get into the water. But very often the statistics are silent on another equally important factor—the cubic space allowed for the completion of combustion of the fuel.

The burning of fuel is a very complex process, of which really little is known, but we do know by experience that it involves several transitions or stages before the whole of the energy of combination between fuel and oxygen has been liberated. Combustion involves the establishing of reversible chemical changes, and the direction in which these proceed will depend on the temperature of the gases. Thus if we suddenly cool the flame in a boiler furnace by bringing it into contact with comparatively cool surfaces, we completely upset the progress of combustion. This is just what happens in a large number of boilers. There is not sufficient space given to complete combustion before the gases come into contact with the boiler tubes. The lower grade coals have a larger percentage of volatile matter, and require proportionately more combustion space.

So far the question has been glanced at from the point of view of the designer. There is, however, a much larger question, or rather one that affects a larger number of people, namely, those whose lot it is to control the firing of boilers as they are not always as they should be. Given a boiler with a combustion space too small for the duty expected of it, the obvious course is to so increase the air supply as to get a very short flame. But this plan defeats itself. Of course, if enough air is supplied we may be tolerably sure that nearly all the carbon has been burned to carbon dioxide and nearly all the hydrogen to water vapor. The trouble is that to insure this with a very short flame we must admit a large excess of oxygen, and with it four times its volume of inert and useless nitrogen, and as a result there is an enormous volume of gases to be passed through the tubes at a very high speed. This gives little chance for the efficient transfer to the water of the heat in these gases, and a lot of the heat goes into the flues. The draft has to be large to secure the necessary air supply. The boiler superintendent is truly on the horns of a dilemma, because to err in the other direction, reducing the air supply, is almost sure to allow much of the fuel to pass unburned and perhaps to choke up the heating surfaces.

Absence of smoke is no proof of proper combustion. There may be large quantities of carbon monoxide passing off invisibly. Measurement of the temperature in the flues, though valuable, is not conclusive evidence. Clearly, if there is a large volume of gases passing through the boiler their temperature may not be very high and still they may be carrying away a great quantity of heat. The smallest amount of air that will secure practically complete combustion is the condition to be aimed at, and the velocity of the gases should be as low as possible, so that they have time to burn and then time to give up their heat to the boiler.

To secure that adjustment of the draft and air supply which gives the highest temperature to the body of fuel will be the first step toward high efficiency. Therefore, a pyrometer is

needed to measure the fuel temperature. If the boiler has any claims to good performance this temperature will be a high one, anywhere from 1400 to 1700° C. Now, such high temperatures cannot be measured with a Le Chatelier couple. No pyrometer that has to acquire the actual temperature to be measured can be used here. It is necessary, therefore, to adopt an instrument which measures the radiant energy given out by the fuel bed. This measurement may be made either with the total heat radiation as by the Fery radiation pyrometer or by the luminous radiation as in an optical pyrometer. The former method is much to be preferred because it does not require a skilled user, but can be satisfactorily used by the ordinary fireman, an advantage not possessed by any of the optical type.

In the December number of this journal the writer described the construction and operation of the Fery radiation pyrometer, and the details do not, therefore, need repeating here. It suffices to sight the pyrometer telescope through a small peephole into the boiler and a direct continuous reading is obtained showing, at will, the temperature of the fuel bed or the furnace walls, arches or other surfaces. Being portable, the pyrometer can be carried around the plant and set up where needed. Once set up, the readings are continuously given in temperature, direct, and may be autographically recorded where desired.

### A New Burette Clamp.

A new form of burette clamp has recently been placed on the market by the Henry Heil Chemical Co., 210 South Fourth Street, St. Louis, Mo. This clamp has the usual iron body and thumb-screw by which the clamp is fastened to the rod of the support. The clamp itself is of stamped steel fastened to a steel screw. It is opened and closed by means of a cone-shaped iron nut which moves freely over the steel screw. The clamp is shown open in Fig. 1. By turning the nut so that it moves outward on the screw the cone engages the projecting ends of the clamp arms and forces them apart so as to close the

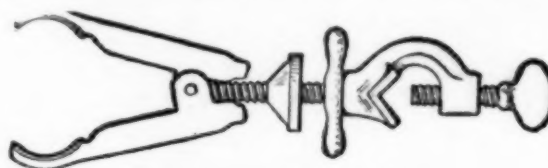


FIG. 1.—BURETTE CLAMP, OPEN.

jaws, as shown in Fig. 2. The clamp can be adjusted to hold a burette or condenser either upright, horizontal or at an angle by use of the check nut.

The obvious advantages of this arrangement are simplicity of construction and the central position of the steel clamp. The projection on the side, usually found with other forms of

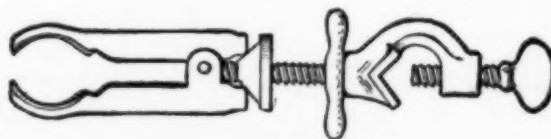


FIG. 2.—BURETTE CLAMP, CLOSED.

clamps, is thus done away with; this allows the chemist to quickly lock and unlock the clamp. The clamp is also cheaper than the usual form, as it contains less parts.

**Vanadium Steel.**—The United Steel Company, of Canton, Ohio, has received what is said to be the largest order for vanadium steel ever placed in this country, from the Ford Motor Car Company, of Detroit. This order calls for 2100 tons in all and includes vanadium steel for springs, vanadium case-hardening steel, and vanadium steel for axles, gears, etc. The new Ford car will be built throughout of vanadium steel.



### Thermo-Electric Pyrometers.

To meet all conditions which arise in practice, the Siemens & Halske Co. is manufacturing all types of pyrometers—especially resistance pyrometers, thermo-electric pyrometers and optical

observing the temperature at any moment or as a combined indicating and recording instrument. The latter instrument affords a continuous check on the workmen day and night and enables the foreman to ascertain any irregularities in firing.

The adoption of the thermo-electrical pyrometer permits of having one indicating apparatus at a distance from the furnace (for example, in the engineer's head office), and another, connected in parallel to it, near the furnace, thus enabling the foreman to control the temperature. Further, it is not necessary to have an indicator for each thermocouple, as by means of a multiple-way switch any number of thermocouples, provided they are of the same type, can be used with one indicator, or a special switch can be supplied for affecting this interchange automatically, an arrangement which allows of up to five thermocouples being used with one recorder as described below.

Thus a large works could be equipped with one or more indicators for the use of the stokers, and another with or without an automatic switch and with a recorder in the office of the superintending engineer.

In selecting materials for the thermocouple it is of the greatest importance that the readings obtained at the highest temperatures should always remain constant.

Platinum and platinum-rhodium conform to this requirement even at high temperatures; both metals can be obtained of great purity and their melting points are sufficiently high so that with such a couple a temperature of 1600° C. can be measured. The relation between the temperature of the hot junction and e.m.f. of the Siemens-Halske instruments is determined for every

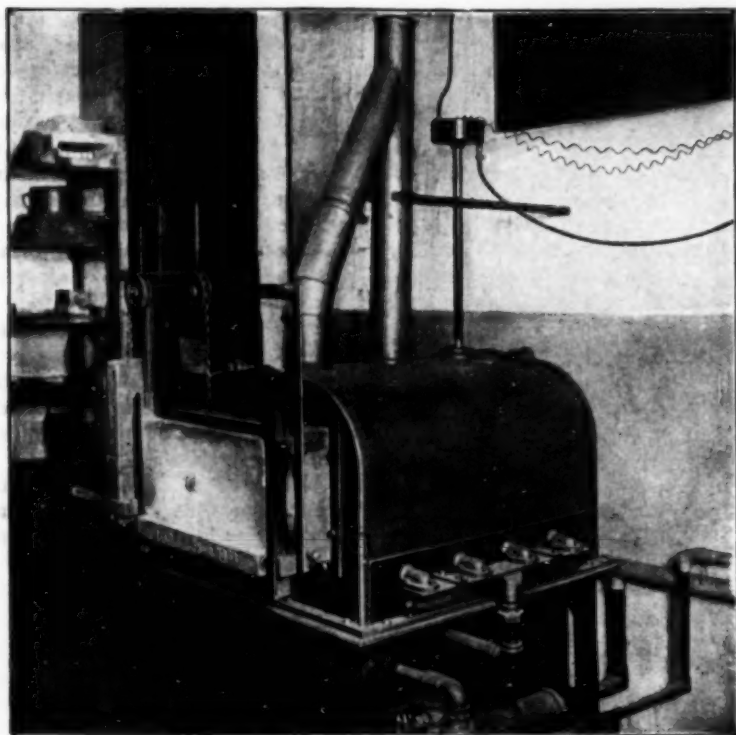


FIG. 1.—MUFFLE FURNACE WITH THERMO-ELEMENT.

pyrometers. A discussion of the special adaptability of these different types of instruments for different purposes may be found in a little pamphlet recently issued by the Siemens & Halske Co., in German, dealing with some typical applications of pyrometers, especially in blast-furnace practice, foundries, annealing and hardening furnaces, boiler plants, porcelain and stoneware factories, chemical works and glass works; in each case the most suitable type of pyrometer is pointed out. We intend to give a review of this very instructive pamphlet in our next issue. The following article is restricted to a description of the latest designs of thermo-electric pyrometers of the Siemens & Halske Co. Further details concerning these and other types of pyrometers made by this company may be obtained either from the Siemens & Halske Co. themselves at 50 Church Street, New York City, or by their sole agent, Mr. Charles Engelhard, 32 Cortlandt Street, New York City.

The field of usefulness of the thermo-electric pyrometer is continually extending; it is used at present in smelting works for measuring the temperature of the hot blast in blast furnaces; in annealing and hardening furnaces; in porcelain kilns; chemical works; glass works; foundries; in steam-raising plants (for measuring the temperature of the superheated steam, flue gases, economizers, etc.), in refuse destructors, etc.

The advantages of the thermo-electric temperature measurement ensure its extensive use in the laboratory as well as in the factory on account of its adaptability to almost every requirement that may arise. Figs. 1 and 2 show the application of a thermo-element to a muffle furnace and a lead-hardening furnace, respectively.

The thermo-electric pyrometer consists essentially of three parts: the bulb, containing the thermo-element with protecting tubes and cooling device; the instrument which indicates or records the temperature, and the wires connecting the bulb with the instrument.

The indicator is made either as a direct-reading apparatus for

thermocouple by the German Reichsanstalt and the results are given on the certificate which accompanies the instrument. The limit of error at the temperature of 1000° C. is about 5° C.

In cases where platinum and platinum-rhodium couples are too expensive, thermocouples of platinum and platinum-iridium will be found reliable enough for all practical purposes up to about 1000° C., but this type is not accompanied by the certificate of the Reichsanstalt.

For measuring moderately high temperatures less costly metals are employed. Silver and constantan couples may be used for temperatures up to 650° C. The couples are supplied with a Reichsanstalt certificate; the accuracy is  $\pm 1^\circ$  C.

Thermocouples are employed for measuring not only high temperatures, but also very low temperatures, and for this purpose couples of copper and constantan are used for temperatures from  $+100^\circ$  C. to  $-190^\circ$  C., which is sufficient for all practical purposes. The couples are supplied with the certificate of the Reichsanstalt; the accuracy is  $\pm 1^\circ$  C.

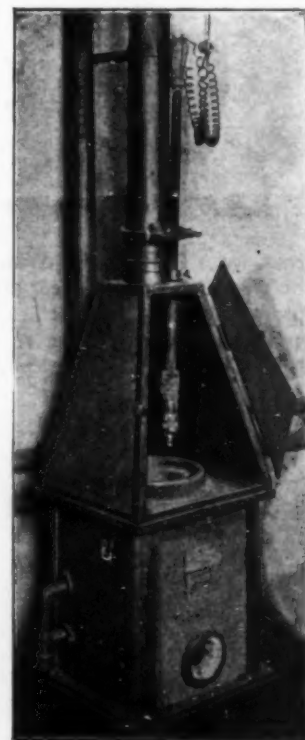


FIG. 2.—LEAD-HARDENING FURNACE WITH THERMO-ELEMENT.

Platinum, platinum-rhodium elements are, therefore, suitable from  $+200^{\circ}$  to  $1600^{\circ}$  C. (or about 400 to  $2900^{\circ}$  Fahr.); platinum-iridium elements from  $+200^{\circ}$  to  $1000^{\circ}$  C. (or about 400



FIG. 3.—PROTECTING TUBE, WITH CAST-IRON COOLING HEAD.

to  $1800^{\circ}$  Fahr.); silver, constantan couples from  $+100^{\circ}$  to  $650^{\circ}$  C. (or  $212^{\circ}$  to  $1200^{\circ}$  Fahr.); copper, constantan couples from  $-187^{\circ}$  to  $+100^{\circ}$  C. (or  $-307^{\circ}$  to  $212^{\circ}$  Fahr.).

The temperature range in which some type of a thermoelement can be used is, therefore, exceedingly large, extending



FIG. 4.—PROJECTING TUBE, WITH WOODEN HEAD.

from  $-187^{\circ}$  C. to  $1600^{\circ}$  C., or from  $-307^{\circ}$  Fahr. to  $2900^{\circ}$  Fahr.

The temperature which is measured by thermocouples is the difference between the temperature of the hot junction and the ends of the thermocouple where they are connected to the indi-



FIG. 5.—KNEE-SHAPED PROTECTING TUBE.

cator leads. In order to obtain accurate readings, the terminals of the couple must be kept at a low uniform temperature and protected from the direct radiation of the furnace. In general, this temperature can be taken as practically near enough to  $0^{\circ}$  C., and the reading shown on the indicator as that of the



FIG. 6.—INDICATOR, WITH SUSPENDED COIL.

hot junction. For more accurate measurements, and especially at moderate temperatures, the temperature of the terminals of the couple cannot be ignored. For this purpose, an ordinary mercury thermometer is placed near the terminals, the temperature is noted and the indicator needle adjusted to show

this temperature on the scale instead of  $0^{\circ}$  C., the indicator being disconnected from the couple at the time.

If this method be not followed, for temperatures above  $100^{\circ}$  C. about half, and for lower temperatures about the full temperatures of the terminals must be added to the readings of the indicator.

For high temperatures thermocouples should not be less than 1 m long, so that the junction is sufficiently far in the furnace to take the full heat therefrom. In using shorter couples the heat is liable to be transmitted to the terminals, thus causing errors. Generally the length of the couple depends upon the method of installing, but it is advisable to have the wires of the couple longer than the protecting tubes, using the surplus length in case of accident for renewal of the junction.

In order to secure the satisfactory economical working of an electrical pyrometer installation special care should be given to the manner in which the pyrometers are fitted up.

It is almost impossible to use thermocouples in a furnace without some method of protection. At the very least the two wires must be well insulated from each other. In addition to this, the thermocouple should be shielded against all mechanical injury, chemical action, and the deleterious influences of gases and vapors.

Platinum, at a high temperature, has a great tendency to combine with carbon and metallic vapors, its physical, chemical and also its thermo-electrical properties being thereby changed.



FIG. 7.—INDICATOR, WITH PIVOTED COIL AND HORIZONTAL SCALE.

Silver, copper and constantan must be protected, while hot, against oxidation.

The ordinary silk covering is only suitable as an insulation for the thermocouple wires at quite low temperatures. For higher temperatures, and not exceeding about  $500^{\circ}$  C., an asbestos covering often provides sufficient insulation. For still higher temperatures porcelain is almost universally employed, the Marquardt quality being especially suitable owing to its high fire-resisting and mechanical properties. This porcelain only becomes soft at temperatures above  $1600^{\circ}$  C. and even then shows no signs of electrical conductivity.

The usual forms adopted for this method of insulation are cylinders or spheres with two holes through which the thermo-



FIG. 8.—INDICATOR, WITH PIVOTED COIL AND VERTICAL SCALE.

couple wires are passed, or two concentric tubes are employed, one wire being passed through each tube and efficiently insulated from each other respectively. The Marquardt double tubes, when treated with fireproof glaze, have the further advantage of being highly impermeable to all gases. For temperatures above about  $1200^{\circ}$  C. they are a particularly suitable protec-



tion for thermocouples, but even then great care must be taken to avoid sudden variations of temperature in order to prevent the tubes from cracking.

Other insulating materials which are more rarely used for high temperatures are quartz-glass, carborundum, magnesia, etc., which have fire-resisting properties, combined with great power of resisting sudden changes of temperature.

At fairly low temperatures, that is below  $1000^{\circ}\text{C.}$  to  $1200^{\circ}\text{C.}$ , it is usual to employ a metal sheath if there are no dele-

Further, it is also permissible to connect several indicators to one thermocouple in order to observe the temperature from separate points and to connect several thermocouples to one indicator by the introduction of an ordinary multiple-way switch.

The indicators follow the variations of temperature quickly and correctly and they are almost dead-beat. They are made in various forms: the moving coil is either suspended by a thin metal strip (Fig. 6) or pivoted (Figs. 7 and 8); those instru-

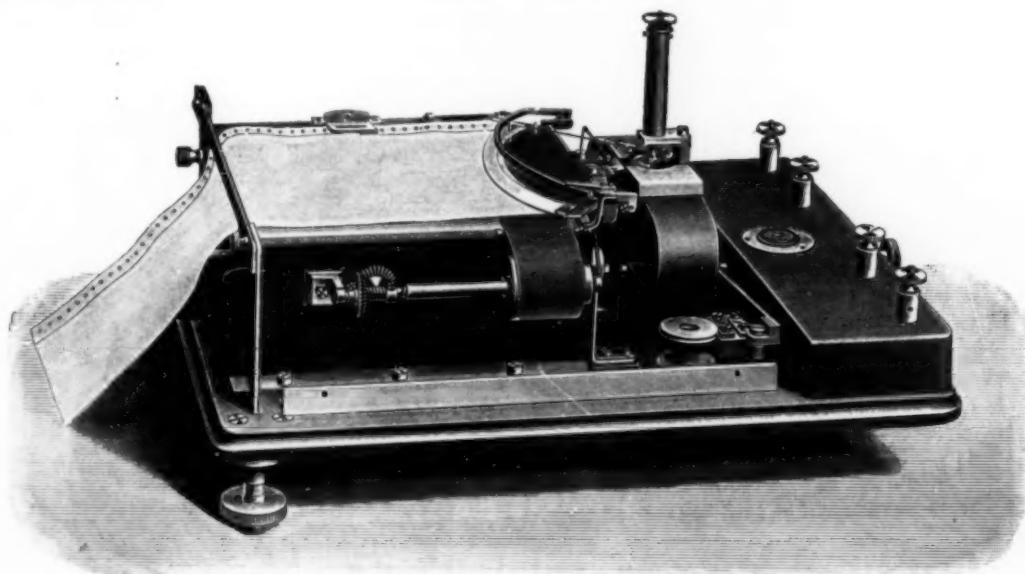


FIG. 9.—RECORDING PYROMETER (CASE REMOVED).

terious gases present, in order to combine better mechanical protection with a slower adjustment of temperature between the porcelain tube and the furnace. This sheath generally takes the form of a tube of iron, steel or nickel, which encloses the porcelain tube and protects it from mechanical shocks. Owing to its greater capacity for absorbing heat and its good heat conductivity, such a sheath also prevents sudden heating or cooling of the porcelain tube.

The instrument showing the temperature is either built as



FIG. 10.—AUTOMATIC SWITCH.

an indicator or a recorder. The indicators are millivoltmeters of the D'Arsonval type with moving coils situated between the poles of a permanent magnet. The high resistance of the instrument is advantageous in that the resistance of the leads connecting the thermocouple need not be taken into account. Consequently, leads of small sectional area can be used; even if of considerable length, it is not necessary to have their resistance calibrated, and a fresh thermocouple may also be used with the same indicator without being specially calibrated.

ments with suspended coils having the advantage of greater sensitiveness in consequence of the absence of friction and a higher resistance, while those with pivoted coils can be easily handled as they need not stand exactly level and are not so sensitive to vibration; they are especially useful in shops where large machines cause vibration.

The recording pyrometer is shown with its case removed in Fig. 9. It is essentially an indicator, either with suspended coil or pivoted coil, provided with a special recording device.

Recently the recording pyrometers with suspended coil are also provided with an alarm bell which indicates when a dangerous maximum or minimum temperature is reached. For this purpose a contact device is used which closes a circuit containing the bell when the dangerous temperature is reached. This contact device is adjustable so that it may be set to any maximum or minimum temperature.

The recording device is so arranged that it requires very little attention.

When only occasional observations are to be made one temperature indicator may be used with a number of thermocouples by employing a multiple-way switch. But this switch is, of course, useless for recording instruments, as these are meant to give a continuous temperature record, so that in this case it would be necessary to have a recorder for every thermocouple.

To overcome this drawback the Siemens & Halske Co. supplies an automatic switch (Fig. 10), which permits of up to five thermocouples being used with one recorder. Of course, the record for each single thermocouple is in this case not strictly continuous, since the instrument can only be in circuit with one couple at a time, but as the records of the different couples follow one another in regular succession it is quite easy to distinguish those belonging to any one thermocouple by the divisions on the chart.

Finally a potentiometer method for thermo-electric testing may be described, which makes use of a principle devised by

Lindeck. This method is used where such a degree of accuracy is required that the variation of the resistance of the thermocouple itself or of any other part of its circuit cannot be neglected.

The principle of this method is that of balancing the unknown e.m.f. of the thermocouple against an adjustable e.m.f., which, in its turn, is determined by a standard resistance and ammeter.

In Fig. 11 *A* represents an accumulator, *W* a rheostat, *M* a millivoltmeter, *T* a thermocouple, and *G* a galvanometer. The

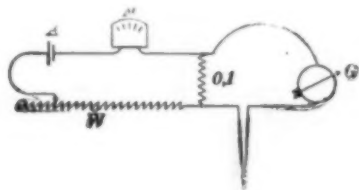


FIG. 11.—POTENTIOMETER FOR THERMO-ELECTRIC TESTING.

main current, the strength of which can be altered by the resistance *W*, produces at the ends of the fixed resistance of 0.1 ohm a potential difference which is exactly balanced by the unknown e.m.f. of the thermocouple when the galvanometer shows no deflection.

If very accurate measurements are desired, e. g., in physiological or thermo-chemical experiments, it is advisable to use a mirror galvanometer instead of a direct-reading galvanometer.

### Metallic Sodium for Drying Transformer Oil.

Metallic sodium is made in this country at the works of the Niagara Electro Chemical Co., at Niagara Falls, by the well-known Castner process.

A novel application of metallic sodium, which will be of interest to the electrical industry, namely, for drying transformer oil to raise the insulating qualities, has recently been studied on a large scale.

The method of using sodium for drying hydrocarbon oils is one that is familiar to every chemist who has ever measured the dielectric constants of these oils where the sodium is usually added in the final operation to remove the very last traces of moisture. In the fear that the caustic formed by the reaction of the moisture on the sodium might be left as a liquid or a solid in the hydrocarbon, the chemist has usually thought it necessary to distill off from the sodium. In working on a very large scale this fear has been found to be groundless, and it is absolutely unnecessary to distill the oil.

Sodium has a density of about 0.97 at 15° C. (59° F.), and melts at 97° C. (207° F.). In transformer oil it will sink unless dragged to the surface by hydrogen gas. With water it reacts to form caustic soda and hydrogen. If very much water is present the caustic soda dissolves, and in the presence of oil forms a second layer. If very little water is present the caustic soda is formed on the surface of the metallic sodium and may be removed when removing the sodium. When the sodium surface becomes covered with caustic it is advisable to remelt under oil, not letting the temperature rise above 120° C. (248° F.). After cooling and getting into the shape desired it is again ready for use for drying more oil. Sodium should always be kept under a good transformer oil.

One method which has been used with transformer oils has been the following:

The oil on the granulated sodium is poured off and a good transformer oil poured over the metal. To the oil which is to be treated, and which is put into an open tank or barrel, the sodium is added at first very carefully, about one ounce to the barrel. If much hydrogen is evolved, this will be conclusive proof that there is much water in the oil, and the balance of

the sodium should be added carefully and in small amounts. The amount which is to be added depends upon the oil, but as a rule one pound to the barrel is usually much more than is required. The oil is then stirred up three or four times a day for a minute at a time. After several days the oil may be removed and tested, but the longer it remains over the sodium the better the oil becomes.

Another method used is to put the sodium in the form of sticks in a cylinder of iron wire of about 28 mesh and hang the cylinder in the oil. This method may be used directly with the static transformer which is in use. The only precautions required being those familiar to all electricians in the avoidance of short circuits.

The Niagara Electro Chemical Co. has repeatedly taken oils which broke down at 3000 volts and, by letting them stand over the sodium for two days, has brought the breaking-down point up to 20,000 volts or more. Results as good as this have been obtained on a large scale by one of the largest Niagara power companies.

Metallic sodium is sold by the Roessler & Hasslacher Chemical Co., of New York City, as agents of the Niagara Electro Chemical Co.

### Coke-Oven Gas Electric Plant.

The London *Elec. Review* of Jan. 22 describes the Bargoed colliery installation of the Powell Duffryn Steam Coal Co. The mine has an output of about a million tons of coal per annum, and its power requirements for pumping, hauling, ventilating, screening, etc., are naturally large. At the Bargoed colliery the small coal, after suitable preparation, is turned into coke, the gases evolved being utilized partly in firing the ovens and partly in driving a large gas-engine plant for generating electrical energy to satisfy the power requirements of the colliery. The yield of gas is some 10,000 cu. ft. per ton of coal, having a heat value of 400 to 440 B.t.u. per cubic foot; the composition of the gas is as follows: Carbon dioxide, 2.01 per cent; oxygen, 0.42; carbonic acid, 5.21; ethylene, 0.80; hydrogen, 63.42; methane, 23.14; nitrogen, 5.0.

The gas is exhausted from the coke ovens and passed through the usual by-product plant, consisting of air coolers, water coolers, bubblers and scrubbers, water, tar and ammonia pumps, into a gas holder of 300,000 cu. ft. capacity, which will shortly be supplemented by a second holder. In order to avoid trouble from dust, the gas from the holder is passed through two groups of purifiers—in which it filters through layers of oxide of iron—prior to use in the large gas engines.

The purifiers, however, serve a double purpose, as the sulphur from the gas, which combines with the iron oxide, is utilized to make sulphuric acid in a suitable plant having a capacity of 10 tons of 70 per cent acid per 24 hours, and this acid is again used, together with ammonia liquor obtained from the gas, in a Wilton sulphate plant, which turns out some 5 tons of sulphate of ammonia per 24 hours.

The yield of ammonia sulphate per ton of raw coal put into the ovens is 19 lb., and of tar 36.5 lb., the respective values being approximately 45 cents and 6 cents.

The power-house equipment is of exceptional interest, as it comprises two double-acting four-cycle Nuremberg gas engines, one of 1200 hp and the other of 2400 hp. These gas engines are coupled with two alternators, the smaller of which has a capacity of 1100 kilovolt-amperes or 825 kw, with a 75 per cent power factor. The larger alternator has an output of 2200 kilovolt-amperes or 1650 kw, with a 75 per cent power factor. The gas engines normally run from Sunday afternoon to the following Saturday afternoon, the interval being utilized for cleaning, and it is usual to clean each cylinder from oil and gas remains every eight weeks. The running staff consists of a driver and cleaner by day and a driver only at night. The smaller 1200-hp engine generated during one year 3,872,000 kw-hours at a running cost of 0.114 cents per kw-hour, exclusive of the cost of gas.



### Dangers of the Transport of Ferrosilicon.

With respect to the article on page 64 of our February issue, Mr. G. WATSON GRAY, consulting chemist of Liverpool, sends us a copy of a letter sent by him to a London *Times* Engineering Supplement, from which we quote as follows:

"It cannot be denied that serious accidents have occurred with some makes of ferro-silicon, but these have all occurred with the alloy containing 50 per cent. or thereabout of silicon, and then only with alloys made at some works, while certain other works making the alloy ever since its introduction have never had an accident or case of poisoning due to their alloy. To me it appears most unfair that because accidents have happened with some makes steamship companies should refuse to carry ferro-silicon altogether, as it is making conscientious and skilful manufacturers suffer for the carelessness of unskilful manufacturers. If the alloy is made with due care with regard to the selection of materials, and under proper scientific control, as is the case at most works, it is a perfectly safe and harmless material. The alloy containing about 50 per cent. silicon has the property of disintegrating when left standing some time after being made, and it is during the disintegration that gases are evolved, if the ferro-silicon should contain any, but it does not follow that if the alloy disintegrates any gases are evolved. As this disintegration alloy is not so suitable for the purpose for which the substance is required, some of the larger manufacturers, following the suggestion I made at the meeting of the Iron and Steel Institute in 1904, have given up the manufacture of the 50 per cent. alloy and are making an alloy containing a higher percentage of silicon which does not disintegrate or evolve gases.

"Some of the letters which have appeared in the newspapers would lead one to believe that the danger of the poisonous and explosive gases was in direct proportion to the amount of silicon contained in the alloy, but this is not so. It is only the 50 per cent. variety which has up to the present caused trouble. Ferro-silicon made in the blast furnace and containing only a comparatively low percentage of silicon, is quite safe to carry, as is the electrically-made alloy containing up to, say, 40 per cent. silicon, and also the alloy containing above, say, 60 per cent. silicon up to 99 per cent., the only quality which need be looked upon with suspicion being that containing between, say, 40 and 60 per cent. silicon, and even then only when it is made at certain works.

"This badly made alloy is dangerous to carry under any circumstances, and if packed, as has been suggested, in hermetically sealed iron drums, the danger of explosion would only be increased, as, in my experience, the presence of moisture is not necessary to cause an evolution of gas. If gas were evolved from material packed in hermetically sealed drums the risk of the drum bursting would be very great.

"Another point is that a number of people conclude that when an explosion of gas evolved from ferro-silicon occurs, it is due to acetylene generated from the alloy which has been made in a furnace previously used for the manufacture of calcium carbide, the alloy having thus become contaminated with carbide. As a matter of fact the largest makers of ferro-silicon do not make any carbide in the works in which the ferro-silicon, or other ferro-alloy is made, and my experience is that the danger is due not so much to acetylene as to phosphuretted and arseniuretted hydrogen. Before I discovered that phosphuretted and arseniuretted hydrogen were evolved from the ferro-silicon which exploded in Liverpool in January, 1904, I and my staff had seen opened and had sampled many thousands of casks of all grades of electrically made ferro-silicon, both in this country and on the Continent, and since the explosion my staff have dealt with larger quantities, as the production has increased during the last four years. None of the people have suffered any ill effects.

"High-grade ferro-silicon has become an absolute necessity in the manufacture of certain classes of steel, and as we have

no facilities in England for the manufacture of this alloy, it must be shipped from the Continent; and in the interests of both our English steel manufacturers and the ferro-alloy makers on the Continent something might be done toward formulating some reasonable regulations with regard to the conditions under which the alloy should be carried, and the precautions necessary to be observed by the steamship companies in storing it."

### Metal Statistics.

The American Metal Market and Daily Iron and Steel Report has just issued its "Metal Statistics" for 1909. These statistics appeared last year for the first time. The second edition is much larger and more complete. It can be safely stated that this little volume of 123 pages will prove very useful for buyers and sellers of metals. It contains tables and data on iron and steel, copper, tin, spelter, lead, silver, antimony, and two appendices of duties on metals, and on English and American price equivalents.

The chief new feature of this year's statistics are the 31 statistical tables on iron and steel, which have been compiled and arranged in a most creditable way by Mr. B. E. V. Luty of Pittsburgh. Several of these tables are of decided originality, like the table of "index steel prices" and the table of total production. The latter is herewith reproduced. It gives the estimated total production up to January 1, 1908, and the production in the year 1907 alone; gross tons except in the case of nails, which are given in kegs of 100 pounds:

	1907.	Total through 1907.
Iron ore .....	51,720,619	675,000,000
Pig iron .....	25,781,361	350,000,000
Open-hearth steel .....	11,549,736	72,000,000
Bessemer steel .....	11,667,549	145,000,000
Total steel .....	23,362,594	320,000,000
Iron rails .....	925	10,700,000
Steel rails .....	3,632,729	54,300,000
Structural shapes .....	1,940,352	19,000,000
Wire rods .....	2,017,581	21,000,000
Cut nails .....	1,109,138	200,000,000
Wire nails .....	11,731,044	147,000,000
Tin plate .....	514,775	4,950,000

Various facts revealed in this table are quite interesting, like the disappearance of the iron rail, and the fact that more cut than wire nails have been made, although now we make ten times the quantity of wire nails. (They date only from about 1886, whereas about the first finished iron made in this country was cut nails.)

The editors and publishers of these "Metals Statistics" must be congratulated on bringing out such a useful and interesting little volume.

### National Chemical Societies

On Saturday evening, January 30, the monthly smoker of the Chemists' Club took place. The newly elected president, Dr. Morris Loeb, announced that Professor Morley had been elected an honorary member of the club in recognition of his splendid record in chemical research and his long and useful career as a professor.

Dr. Baskerville, in a few words, then described the importance of the work Professor Morley has done for science. Then Dr. Morley after receiving a beautifully illuminated resolution signed by all the members present, thanked the Chemists' Club.

Dr. W. R. Whitney, the new president of the American Chemical Society, was also a guest of honor, and Dr. Baekeland, as chairman of the New York section of the American Chemical Society, welcomed him to the club in a short speech, of which we extract the following, because it has a direct bearing on an editorial in our February issue:

"The American Chemical Society has entered upon a new era of unprecedented activity. Thanks to the efforts of President Bogert, we have entered into a system of subdivision, which will give full scope to all the branches of chemistry in

which our many members are engaged. After adding to our regular Journal a very complete and useful Journal of Chemical Abstracts, we have now started a Journal of Industrial Chemistry and Chemical Engineering.

"It was very gratifying to feel after this excellent work had begun, that in a man full of keen activity and enthusiasm like Dr. Whitney, we shall find another able leader who will help to develop a brilliant future for our Chemical Society.

"Henceforth, every English-speaking chemist, whatever may be his specialty, ought to feel that it is his own interest to become a member of the Chemical Society.

"At the same time I shall take this occasion to state emphatically that I do not share the opinion of one or two of my friends who think that ultimately there will be no use nor excuse for any other chemical organization in the United States. Quite to the contrary, I believe that such societies as the American Electrochemical Society and the Society of Chemical Industry have abundantly proven their great usefulness and strong vitality. Even were it possible to consolidate with them, it would be undesirable because I believe that it would be harmful to the best interests of the future development of chemistry in this country. Consolidation or trustification may be an excellent thing for mediocrities, but can never do any good where individualism and superior personal effort show paramount.

"The Chemists' Club, bringing all the members of these different societies together has been the flux that strengthens the alloy which makes the backbone of our prosperous sister societies."

### Advantages of Acetylene Lamps for Miners.

By A. CRESSY MORRISON.

For several years acetylene has been used in miners' lamps in France, Germany and Belgium to a large and steadily increasing extent, until at present it is used almost exclusively in over 200 mines and by approximately 50,000 men. The light is satisfactory, saves nearly 50 per cent of the cost, giving more and better light. Mining engineers have been more or less familiar with this fact, but the introduction of acetylene into mines, up to the last two years, has been very slow in this country. Its use is now, however, coming to be recognized as an important advance, and it promises shortly to replace all other means of illumination, except in special cases.

It is seldom that an improvement in quality or advantage is accompanied by reduction in cost, but this is really the fact in the case of acetylene.

Candles, which are largely used throughout our Western mines, remove seven times, and kerosene five times, as much oxygen from the air of the mines as acetylene. The products of combustion given off by candles are ten times and from kerosene nine times as much as that given off by acetylene. The difference in the deterioration of the air in the mines is, therefore, enormous. While acetylene in a mine gives off no smoke whatever, every miner is familiar with the difficulty from the products of combustion given off by other illuminants. Acetylene, therefore, makes for the life and comfort of the miners, protects them from the degenerating effects of insufficient oxygen, and removes the one important cause of lung and throat troubles. The actual amount of illumination given by candles and kerosene is lessened by a very large percentage by the smoke and mist which so rapidly accumulate, whereas all the light given by acetylene reaches the point to be illuminated, without any interference whatever.

It has been found, in actual experience, that in entries which are 60 ft. to 70 ft. ahead of the air, there is not the slightest particle of smoke from an acetylene lamp and the entry is just as clear at the end of a shift as it was at the beginning.

An interesting thing about acetylene is the tenacity of the flame. It is not easily blown out, the rapid motion of the

miner will not cause it to flicker badly, and it burns brilliantly in an atmosphere so foul that candles fade and go out. In fact, acetylene will not deprive the miner of light until the atmosphere is so bad it will not support life.

For underground surveying and mine inspection, the use of acetylene is of great importance. Maps and records escape the usual accompaniment of grease and smudge. The acetylene flame is so small and clear that it affords an accurate point on which to sight instruments.

Another use for acetylene in somewhat larger units is found where the rays are concentrated by a reflector, in which case a brilliant illumination can be thrown into inaccessible places where distant bays, high backs, caved places and other difficult and otherwise hidden parts of the mine can be explored with convenience, and in case of emergency, without danger.

Acetylene is especially advantageous as a cap lamp for drivers, and it has been found, where mules are used, that they can see much better and are not nearly so liable to stumble.

The very bad quality of oil for miners' use, which has in some States called for laws establishing a standard quality—laws, by the way, which are frequently violated by a species of adulteration which almost defies detection—is becoming another powerful argument in favor of the substitution of some illuminant which can not be adulterated.

In actual practice, 8 oz. of calcium carbide, at 4 cents per pound, or 2 cents' worth of carbide, will give nearly 10 cp of light for 10 hours, while candles in many parts of the country, counting four candles to the 10-hour day, would cost 5 cents per day. There seems, therefore, to be no reason why acetylene should not be introduced, provided a proper lamp at an economical price can be devised. As a matter of fact, practical experience has demonstrated that some of the acetylene miners' lamps now upon the market meet all the necessary requirements both as to economy, lasting quality and practicability in use. Miners' acetylene lamps are now frequently found in mines throughout the country, especially in Pennsylvania, New Jersey and Illinois. The New Jersey Zinc Co., of New York, which has adopted acetylene illumination for all its mines, has probably more lamps underground than any one concern. The number of miners' lamps in use in the mines of this company is about 3000, and it has been found, in practical use, that the saving is at least 2 cents per day for every miner. The whole method of using acetylene is so simple, and the lamps now in practical use are so satisfactory that the subject of better illumination in mines is worthy the attention of every mine owner and engineer; in fact, the obtaining of better illumination at half the cost, with greater output, safety, comfort and, above all, with better health to the user is so vitally important that the subject must be investigated soon by all mine managers.

### Notes.

The American Institute of Mining Engineers started its New Haven meeting on February 24 with numerous papers discussing the comparative advantages of the sea-level and lock-type for the Panama Canal.

**Cast-Iron Enamel Apparatus.**—The almost unlimited possibilities of enamelled cast-iron apparatus for many purposes of the chemical industries are well known. Mr. J. W. Sittig, importer of German stoneware, states that he is now paying particular attention to the introduction of imported enameled cast-iron apparatus in this country.

The unsatisfactory aluminium market situation has resulted in the taking up of new electrochemical processes by aluminium manufacturers. This is no new development, as it will be remembered that the large aluminium works at Froges in Savoy were the birthplace of Heroult's work on ferroalloys and electric steel. It is reported that they are now also experimenting with the Guye process for making nitric acid for air. The same is reported from the Neuhausen aluminium company, where the Moscicki process is to be used.



**Electric Zinc in Canada.**—We have repeatedly noted the work of Mr. Fred. T. Snyder on the use of the electric furnace for zinc reduction. It is now reported that his process has been successfully reduced to commercial operation and that spelter and lead-silver bullion are being produced on a considerable scale at the electric furnace plant of the Canadian Zinc Company in Nelson, British Columbia. The ores treated average about 40 per cent. zinc, 10 per cent. lead and 12 ounces silver, with  $1\frac{1}{2}$  per cent. copper. The present furnace capacity of the works is 10 tons per day, but is soon to be trebled.

The **National Carbon Co.** of Cleveland had a fine exhibit at the recent electrical show in Chicago, showing a line of graphite and carbon electrodes for electric furnace work up to 10 inches square cross section and about 18 inches long. This is a stock pattern. They are made up to 12 inches diameter round. They also exhibited several carbon crucibles, carbon plates and ordinary electrodes.

The **Mechanical Appliance Company**, Milwaukee, Wis., exhibited at the recent Chicago Electrical Show an electric flour "sterilizer and ager" which has been built for the use of the Alsop Process Company. This sterilizer consists of an iron box containing revolving rollers which are connected to a high-pressure spark coil. Current for this coil is provided by a 500-volt generator which is located on top of the sterilizer. A current of air is provided in this sterilizer for blowing out the arc and carrying off the nitrogen oxide and ozone gases which are formed by the arc. These gases age and sterilize the flour by passing up through it.

**Electric Steel.**—According to the *Manchester Guardian*, a new plant for the electrical manufacture of steel has been set to work at Flekkefjord, in Norway. The method employed is that patented by Hiorth (described in our Vol. VI, p. 143). At first the output will consist chiefly of high-grade tool steel, though it is the intention in future to manufacture plates also. The iron is being imported from Sweden, and converted into steel in the electric furnace, the energy being derived from water power in the neighborhood. The enterprise is being financed chiefly by Dutch capital. No particulars are given as to the output. (*Lond. Electrician*, Jan. 29.)

**Iron and Phosphorus.**—A thesis of Dr. B. Saklatwalla, presented to the Institute of Technology of Berlin (Berlin, 1908), gives an account of a thermic and metallographic investigation of the compounds of iron and phosphorus. Great care was taken to use pure electrolytic iron and pure phosphorus, and exclude any carbon. The chief results are as follows: The melting point of a chemically pure iron in a nitrogen atmosphere is  $1510^{\circ}$  C. Phosphorus forms with iron up to 1.7 per cent a solid solution. This solid solution forms with  $\text{Fe}_3\text{P}$  a eutectics with 10.2 per cent phosphorus and a melting point of somewhat above  $1000^{\circ}$  C. Between  $\text{Fe}_3\text{P}$  and  $\text{Fe}_2\text{P}$  there exists a eutectics with about 16.2 per cent phosphorus and a melting point of  $960^{\circ}$  C. By melting between 20.5 and 21.7 per cent phosphorus, no eutectics is formed, but "mixed crystals." Between  $\text{Fe}_2\text{P}$  and the next higher phosphide there is probably again a eutectics with a melting point of  $1218^{\circ}$  C. The hardness does not increase directly with the content of phosphorus. The hardness has maximum values at the eutectic points.

**Wisconsin Section American Electrochemical Society.**—The Wisconsin section of the American Electrochemical Society has been holding regular meetings at Madison, Wis., during the last few months. At the December meeting Mr. James Astén presented a paper upon the subject of "the iron-carbon series of alloys." Mr. Astén is working with Prof. Burgess under the Carnegie Institute grant for research on electrolytic iron. At the January meeting Prof. C. F. Burgess read a paper upon the subject of "the corrosion of boiler locomotives." This subject was treated from the electrochemical corrosion standpoint. At the February meeting Mr. C. I. Zimmerman gave a talk upon the subject of "some electric furnace prod-

ucts from sand." The various products, such as carborundum, silicon, monox, fused silica, silundum, siloxicon, and the various silicon alloys, were briefly discussed.

The first issue of a new journal, "**How**," contains a suggestive note on an important improvement in a manufacturing process due to accepting the advice of a consulting chemist (who, in this case, was Mr. Fred J. Maywald). The note is significant of the increasing interest of the non-technical public and of general manufacturers in chemical engineering.

Mr. C. O. Mailloux, consulting electrical engineer of New York City, has opened in connection with a French electrochemical engineer, M. Delton, an international electrochemical engineering office with headquarters in New York and Paris. M. Delton has been identified with some of the most important electrochemical industries in Europe; he has designed, constructed and operated numerous electrochemical plants, and he is at present the technical adviser and consulting engineer of a large number of electrochemical concerns in various countries. The new consulting engineering firm has at its disposal practically all the experience and data of dozens of plants; not only the specifications, the general and the detail plans, and all the construction data, but also all the records of tests, and details regarding cost of production at every stage; also profits, etc. The following list gives the principal electrochemical processes on which the firm has reliable data. Production of pure alumina, artificial cryolite, and aluminium; calcium carbide (electric furnaces up to 5000 kw); production of ferroalloys, including ferro-silicon, chromium, manganese, molybdenum, tungsten, vanadium, titanium; production of steel by the electric furnace; production of phosphorus by the electric furnace; electrolysis of sodium chloride by all processes, including diaphragm cells, mercury cathode cells, and gravity ("bell") cells; production of chlorine compounds; chloride of lime, hypochlorite of lime, chloride of sulphur; tetrachloride of carbon, chloride of lead; liquid chlorine; production of potassium chlorate, or sodium chlorate by direct electrolysis; extraction of sodium chloride, by multiple evaporation system; steam and hydraulic power plants for power transmission, and distribution, and for electrochemical plants.

The **National Council of Commerce** has just issued the *Proceedings* of its first annual meeting, held at the office of the Secretary of Commerce and Labor, in Washington, on Dec. 10, 1908. Secretary Oscar S. Straus made the chief address, outlining the scope of the new organization. According to the by-laws which were adopted the objects of the National Council of Commerce are (a) to receive reports and communications from commercial and other bodies as to their needs in the promotion of foreign and domestic commerce; (b) to receive and act upon information and suggestions from the departments of the United States government of interest to the business world; (c) to furnish the Secretary of Commerce and Labor and other representatives of the United States government with authentic information as to the needs and conditions of different industries; (d) to suggest special investigations abroad by agents of the Department of Commerce and Labor; (e) to act as an intermediary between that and the other departments of the United States government and the commercial and trade bodies in arranging for the representation of American products at international expositions; (f) to confer with the departments of the United States government with a view to promoting the trade interests of the country; (g) to confer with the Secretary of Commerce and Labor regarding legislation necessary to promote foreign and domestic commerce or adequately to equip his department for such work; (h) to promote friendly co-operation between commercial organizations throughout the United States. Eligible to membership are all commercial and industrial associations in good standing in the United States and similar associations in foreign countries composed of or controlled by citizens of the United States, residing and doing business abroad. The yearly

membership fee is \$100. Mr. Gustav H. Schwab, of New York City, is the chairman of the council. Among the members of the council are the American Hardware Manufacturers' Association (Charles W. Asbury) and the National Wholesale Druggists' Association (Wm. Jay Schieffelin).

### Personal.

Dr. and Mrs. Paul Héroult sailed for France on Feb. 18. Dr. Héroult intends to return to this country in three or four months.

Dr. Eugene Haanel, Director of the Canada Department of Mines, Mines Branch, has returned from Sweden, where he investigated a new process of reduction of iron ore in the electric furnace at the works of the Electro Metal Co., Ludwika, Sweden. While it is reported that the results of the investigation have been very satisfactory, the first official account will be given in a report of Dr. Haanel to the Canadian government.

Mr. Louis Simpson has resigned as general manager of the Montreal Cotton Co., of Valleyfield, Quebec, in order to devote all of his energies to the promotion and furtherance of electric iron and steel industries in Canada.

Dr. Franz Meyer has resigned as director and treasurer of the Metallurgical Co. of America and has returned to Germany to enter as partner into the firm of R. Wedekind & Co., in Uerdingen (Niederrhein).

Mr. I. J. Moltkehanen has resigned as manager of the A. S. Vadheim Electrochemiske Fabriker, in Norway, and has established an office at Brussels, Belgium, as consulting engineer, especially for electrochemical industries desirous of acquiring cheap water powers in Norway.

### Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

#### ELECTRIC FURNACES (Continued).

585,040, June 22, 1897, C. G. P. De Laval, of Stockholm, Sweden.

Resistance type. A furnace for melting or heating metals and other materials. The furnace is a pot of iron lined with refractory material. In its lower part is a transverse bridge of refractory material, containing a water-cooled passage. The electrodes are horizontal iron bars of opposite polarity which extend through the sides of the furnace into the lower ends of the cavities at each side of the bridge. Sealed inclined tap holes for the molten metal extend through the opposite walls. In operation, the metal to be melted is introduced through a charge-opening in a cover lying on top of the furnace, comes in contact with the iron electrodes and is melted by resistance. If desired, an electrolyte, such as molten magnetic iron ore, may occupy the lower part of the furnace chamber, being heated by an alternating current passing between the iron electrodes. The metal to be melted is then fed into this electrolyte and is thereby heated. A lateral tap hole serves to maintain the electrolyte at a predetermined level. The electrolyte is used merely as a means of heating and effects no reduction.

586,686, July 20, 1897, Robert F. S. Heath, of Camden, N. J.

Arc type. This furnace, primarily for the production of calcium carbide, has a vertical cylindrical chamber with a non-conducting lining. One electrode is a horizontal circular metal pan containing a hearth of broken carbon and rotating on a central support. The other electrode consists of a series of depending carbon bars, carried in an adjustable metal head. The lower ends of these bars extend over the hearth at one side only. A feed hopper discharges over the opposite side of the hearth. In use, the hearth electrode is slowly rotated; the charge mixture is gradually fed in, being distributed over the

hearth by its rotation, and is reduced as it comes within the field of the arc. The molten carbide may be tapped out through a lateral hole in the hearth, or may be allowed to accumulate, the hearth then being rolled out of the furnace through a suitable door. The tap hole may be opened by forcing a pipe through a hole in the side wall of the furnace and into the tap hole, displacing its plug.

586,687, July 20, 1897, Robert F. S. Heath, of Camden, N. J.

Arc type. This furnace, primarily for the production of calcium carbide, consists of a vertical chamber of refractory material having a non-conducting lining. The cathode is a hearth of broken carbon. The other electrode is a series of depending carbon rods, carried by a metal holder, with their lower ends at one side of the hearth. A feed hopper extends to the other side of the hearth, having a cut-off valve and a conveying screw. The metal holder of the vertical electrodes is laterally adjustable in a bar which is vertically adjustable on a central rotating shaft. In use, the lower ends of the electrodes sweep over the hearth in an annular path; they are simultaneously raised as they rotate by automatic mechanism.

586,822, July 20, 1897, Francis J. Patten, of New York City.

Arc type. The furnace consists of a vertical chamber having a carbon hearth and a depending carbon electrode. The hearth is surrounded by a magnetic ring having a closed Gramme winding with four leads, supplying biphasic alternating currents. An arc is sprung between the hearth and depending electrode, and is caused to rotate by the rotating magnetic field set up in the ring. In a modified construction, the depending electrode is a carbon tube, or two concentric tubes. Arcs are sprung between the lower ends of the depending carbon tubes and the hearth. The magnetic ring is protected from the heat by a wall of fireclay. The charge mixture may be fed into the furnace through the tubular electrodes. The molten product is withdrawn through a lateral tap hole at the base of the chamber.

586,824, July 20, 1897, Francis J. Patten, of New York City.

Resistance type. The furnace is a vertical chamber of brickwork having central carbon-rod terminals entering its base and top. A magnetic ring supplied with biphasic alternating current surrounds the chamber. In use, a thin carbon pencil is placed between the carbon terminals or electrodes and the charge mixture, for example, lime and carbon, is fed into and fills the chamber. The carbon pencil is heated by resistance and reduction proceeds in proximity to it. Alternating current is simultaneously supplied to the magnetic ring, producing a rotating field which tends to deflect the current away from a vertical line joining the electrodes, and thus to force the zone of reduction outward into the unreduced charge. The resulting nugget of calcium carbide is withdrawn and the process repeated. The carbon pencil used to start the current is consumed, and a new one is inserted in recharging the furnace.

### NEW BOOKS.

LABORATORY NOTES ON INDUSTRIAL WATER ANALYSIS. A survey course for engineers. By Ellen Henrietta Swallow Richards. 52 pages. Bound in cloth. Price, 50 cents. New York: John Wiley & Sons.

FOUNDRY PRACTICE. A treatise on molding and casting in their various details; prepared for the use of students in the College of Engineering, University of Minnesota. By Ja. M. Tate and Melvin O. Stone. 240 pages. Bound in cloth. Price, \$2. New York: John Wiley & Sons.

LEATHER INDUSTRIES LABORATORY BOOK OF ANALYTICAL AND EXPERIMENTAL METHODS. By Richardson H. Proctor. 480 pages. Bound in cloth. Price, \$7.50. New York: Spon & Chamberlain.

FACTORY GLAZES FOR CERAMIC ENGINEERS. Arranged (on an exhaustive method) for the heat of the soft porcelain kiln and including the glazes employed in actual manufactories by the



foremost manufacturers of the finest products; with improvements thereon and additions thereto. A of the series. Bound in cloth. Price, \$10 net. New York: Spon & Chamberlain.

**HYDRAULICS AND ITS APPLICATION.** By A. H. Gibson. 773 pages. Bound in cloth. Price, \$5 net. New York: D. Van Nostrand Co.

**MODERN POWER GAS-PRODUCER PRACTICE AND APPLICATIONS.** A practical treatise dealing with the gasification of various classes of fuels by the pressure and suction system of producer. By Horace Allen. 834 pages. Bound in cloth. Price, \$2.50. New York: Van Nostrand Co.

**THE ECONOMY FACTOR IN STEAM POWER PLANTS.** By G. W. Hawkins. Bound in cloth. Price, \$3. New York: Hill Publishing Co.

**THE STEAM TURBINE.** A practical and theoretical treatise for engineers and designers, including a discussion of the gas turbine. By Ja. Ambrose Moyer. 377 pages. Bound in cloth. Price, \$4. New York: John Wiley & Sons.

**APPLIED MECHANICS FOR ENGINEERS.** A text-book for engineering students. By Lee E. Hancock. 396 pages. Bound in cloth. Price, \$2 net. New York: Macmillan Co.

**NEW LABORATORY MANUAL OF PHYSICS.** By S. E. Coleman. 264 pages. Bound in cloth. Price, 80 cents. New York: American Book Co.

**ELECTRIC MOTORS; THEIR INSTALLATION, CONTROL, OPERATION AND MAINTENANCE.** By Norman Gardner Meade. 164 pages. Bound in cloth. Price, \$1 net. New York: McGraw Publishing Co.

**THE RADIOACTIVE SUBSTANCES, THEIR PROPERTIES AND THEIR BEHAVIOR.** By Walter Makower. 301 pages, illustrated. Bound in cloth. Price, \$1.75 net. New York: Appleton.

**RADIO-TELEGRAPHY.** By C. C. F. Monckton. Bound in cloth. Price, \$2 net. New York: D. Van Nostrand Co.

**AN INTRODUCTION TO PRACTICAL MATHEMATICS; WITH DIAGRAMS.** By F. M. Saxelby. 226 pages. Bound in cloth. Price, 80 cents. New York: Longmans, Green & Co.

**PATENTS AS A FACTOR IN MANUFACTURING.** By Edwin Jay Prindle. 141 pages. Bound in cloth. Price, \$2. New York: Engineering Magazine.

**THE DELAYS AND DEFECTS IN THE ENFORCEMENT OF LAW IN THIS COUNTRY.** By W. Howard Taft. 23 pages. Paper binding. Price, 10 cents. New York: Civic Forum.

## BOOK REVIEWS.

**METALLURGICAL CALCULATIONS.** By Joseph W. Richards, A.C., Ph.D., professor of metallurgy in Lehigh University. Part III. Metals other than iron (non-ferrous metals). 208 pages. Price, \$2. New York: McGraw Publishing Co. This third volume completes Dr. Richards' monumental work. The first volume deals with chemical and metallurgical principles in general, the second volume with their special application to iron and steel metallurgy, and the third volume with applications to the metallurgy of the non-ferrous metals. The three volumes are paged consecutively, and the third volume contains an index for the whole work. The metals dealt with in this volume are copper, lead, silver and gold, zinc, mercury and aluminium.

An evidence of the appreciation of the work by the metallurgical world is the fact that translations of the book into four languages have been made. The first volume of an Italian edition has just appeared. A French translation is to appear in serial form in the *Revue des Mines et de la Metallurgie* and later in book form. The first two volumes of a Russian edition are in press, and a German translation is in preparation. The bulk of the work was published originally in serial form in *ELECTROCHEMICAL AND METALLURGICAL INDUSTRY*, from March, 1906, to July, 1908.

**THE MINERAL INDUSTRY.** Its statistics, technology, and trade. Vol. XVI: year 1907. Edited by Walter Renton Ingalls. 1127 pages. Price, \$10. New York: Hill Publishing Co.

It is clearly an impossibility to review concisely a work of this size and scope. Besides, the general character of this annual publication is well known to everybody interested in metallurgy and mining. It must suffice to state here the chief impression which the reviewer received from a careful study of its contents. This is that the very high standard set by the late Richard P. Rothwell is being fully maintained by Mr. W. R. Ingalls with remarkable and even increasing success. The thanks of the metallurgical profession are due both to editor and publisher for this work which must be a work of love to a large extent, but which is a work of which the whole metallurgical profession of this country may justly be proud.

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**LABORATORY EXPERIMENTS IN METALLURGY.** By Albert Sauveur, professor of metallurgy and metallography in Harvard University, and H. M. Boylston, instructor in mining and metallurgy in Harvard University. 73 pages, illustrated. Price, \$1.25. Cambridge, Mass.: The authors.

This work comprises notes on 26 carefully selected experiments in metallurgy. In each case concise instructions are given concerning the procedure to be followed, with useful tables and often with references to standard works or papers on the subject under discussion. For each experiment a blank is added which the student is intended to fill out as his report of the experiment.

Naturally, the work is limited in its scope, as it deals with 26 special experiments only, but these are well chosen, and conscientiousness in carrying them out will fully award the efforts of the student and will give him a grasp of at least some of the most important subjects of metallurgy. The work has been primarily written for the use of Harvard students taking the courses in general metallurgy and in the metallurgy of iron and steel. But the reviewer joins the authors in the hope that "these notes may prove suggestive, at least, to other teachers and students in metallurgy, and even to practitioners of the art."

The first 13 experiments refer to general metallurgy and deal with the following subjects: Coking and proximate analysis of coal; calorimetry (the Parr calorimeter); pyrometry (the Siemens water pyrometer); the Mesuré and Nouel optical pyrometer; and the Le Chatelier thermoelectric pyrometer; determination of the melting points of tin, lead and zinc; reduction of copper oxide by carbon; reduction of lead oxide by carbon; reduction of iron oxide by metallic aluminium (the thermit reaction); reduction of copper oxide by copper sulphide.

The second part of the book deals with the metallurgy of iron and steel and contains again 13 experiments. These are selected to illustrate the influence of carbon and nickel upon the tenacity, elasticity and ductility of iron; the thermal critical points of steel, and the changes in magnetic properties occurring at the thermal critical points; the relation between the critical points and the hardening power of steel; the brittleness produced by hardening and the hardness produced in high-carbon steel by sudden quenching from a high temperature; the influence of hardening upon the ductility, elasticity and transverse strength of steel; the influence of carbon upon hardness and hardening power of steel; the influence of the nature of the quenching bath upon the hardening of the steel; tempering of hardened steel; the influence of certain heat treatments upon the physical properties of steel; the effect of annealing upon the properties of cold-worked steel; the effect of heat upon the grain of steel.

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**LABORATORY GUIDE OF INDUSTRIAL CHEMISTRY.** By Allen Rogers, Ph.D. 158 pages, illustrated. Price, \$1.50. New York: D. Van Nostrand Co.

Dr. Rogers is instructor in industrial chemistry in the Pratt Institute, in Brooklyn. His book follows rather original lines, as indicated by the following remarks in the preface:

"In the average course of chemistry as taught in our tech-



nical schools there is little or no attempt made to bring the student in close touch with manufacturing conditions. This state of affairs is exceedingly difficult to understand, when we consider the large amount of time devoted to practical work in some of our engineering courses.

"The factory is surely no less fertile a department of this industrial era than the railroad or the foundry. For in the manufacturing plant there is more need of techno-practical (if such a term may be used) trained men than in any other branch of industry. Unquestionably it is necessary to have organization for the manipulation of power, machinery and labor, so as to obtain the maximum of production with the minimum of expenditure or depreciation of plant. But in addition, it is highly essential that we understand the chemical principles upon which these industries are based.

"The object of this book, therefore, is to acquaint the student of chemistry with a few commercial processes, by introducing practical methods of handling materials on a large scale; the care and use of machinery; the cost of raw material; transportation; cage system; the handling of men and shop discipline.

"The subject-matter of this book presupposes a certain knowledge of chemistry, and purposely leaves many of the minor details to be worked out by the student. Great leeway is also given to the instructor in order that he may exercise his own originality."

The first chapter gives very brief notes on evaporation, filtration, etc., and deals especially with the various methods for determining the density of liquids.

The second chapter deals with inorganic preparations; aluminium sulphate, antimony-potassium tartrate, ammonium sulphate, barium chloride, etc. In each case the necessary quantities of the raw materials are determined and an estimate of the cost per pound is made. The author recommends to carry out his work on the "foremanship system."

One man is assigned as foreman of the "chemical works" and has as his assistants three or more of his classmates. The work which he is given may be the manufacture of barium chloride, for example. He first has his men make an analysis of witherite to determine the percentage content of barium and also test the strength of the hydrochloric acid. In order that the work may be more commercial he is told to estimate the cost of producing 15,000 lb., it being understood that all weighings are made in grams. The necessary quantity of mineral is then weighed, crushed and treated with the diluted acid in the kettle. During such a preparation as this it will be necessary to remove impurities, this being regulated by analytical tests.

The following chapters deal with the dyeing of textile fibers; the preparation of commercial organic compounds, coal-tar colors and synthetic oils; pigments and lakes; driers, varnishes, paints and stains; soap and allied products; leather manufacture; wood fiber pulp and paper. In each chapter references are added to standard works on the subject discussed.

The book is certainly very suggestive and a valuable contribution to the very scarce literature on the teaching of industrial chemistry.

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#### RAPID METHODS FOR THE CHEMICAL ANALYSIS OF SPECIAL STEELS.

STEEL-MAKING ALLOYS AND GRAPHITE. By Charles Morris Johnson. 221 pages, illustrated. Bound in cloth. Price, \$3. New York: John Wiley & Sons.

The rapid growth during the last decade of the industry of special steels, especially high-speed tool steels, has brought into existence quite a number of serious and difficult special problems of analysis which had to be solved by the chemists of special steel works. The book, here under discussion, is the first giving a systematic record of extended work in this field.

The author is the chief chemist to the Park Steel Works, of the Crucible Steel Company of America, and is, therefore, well qualified to write on this subject with authority. A large number of the methods described appear to be original with the author.

The book has 16 chapters, of which the first 13 deal with the following problems of analysis: Qualitative tests for chromium, vanadium, copper, titanium, nickel, molybdenum and tungsten in steel; analysis of vanadium steel and ferrovanadium; analysis of titanium steel and ferotitanium; analysis of tungsten powders; analysis of tungsten steel and chrome tungsten steel; analysis of low-percentage tungsten steel; analysis of molybdenum powders; analysis of tungsten-molybdenum steels; analysis of ferro-chrome, chrome ore and carbonless chrome; determination of aluminium steel; determination of copper in steel and pig iron; separation of nickel and copper from iron and vanadium by potassium ferricyanide; determination of copper in metallic copper; rapid determination of nickel in the presence of chromium, iron and manganese; analysis of ferro-manganese; rapid volumetric method for manganese in the presence of iron, calcium and magnesium; determination of carbon in iron and steel by direct ignition with red lead or litharge; determination of carbon in steel, ferro-alloys and plumbago by means of an electric combustion furnace (also by gas and blast); carbon in steel by color; phosphorus in steel, pig iron, bar iron and wash metal; sulphur in steel, bar iron, pig iron and wash metal; manganese in special steels, bar iron and wash metal; silicon in iron and steel; analysis of graphite and graphite crucibles (containing interesting notes on the occurrence of carborundum in old plumbago crucibles).

The fourteenth chapter deals with the annealing of plain and special steels; much useful information is here condensed in less than nine pages. In the fifteenth chapter a simple method of calculation is described for finding the amount of water to be added to a concentrated solution in order to dilute it to a given lower percentage. In the last chapter the construction of a practical automatic steam water still and a simple laboratory method for making clay combustion boats are described.

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METALLIC ALLOYS. THEIR STRUCTURE AND CONSTITUTION. By G. H. Gulliver, Lecturer in Engineering at the University of Edinburgh. 254 pages, 104 illustrations. Price, \$2 net. Philadelphia: J. B. Lippincott Co.

This book is not a guide to the practical details of manufacturing alloys, but is an investigation of the theory of alloys on a systematic basis. Two preliminary chapters treat briefly of the theory of solution, of chemical equilibrium as applied to alloys, and the apparatus useful in the scientific examination and testing of the properties of alloys. This is followed by chapters discussing in detail illustrations of binary alloys in which no compounds are present, binary alloys in which definite chemical compounds exist, and ternary alloys of both kinds. The particular alloys described are chosen as typically illustrating the classes, and no attempt at a complete description of all known alloys is made. The work is therefore didactic rather than encyclopædic and must be thus judged. From this point of view it is decidedly a well-written book, adding very little to the store of known facts, promulgating hardly a new idea, but giving a well-balanced picture of the theory of the subject.

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PRACTICAL CALCULATIONS OF TRANSMISSION LINES (for distribution of direct and alternating currents by means of overhead, underground and interior wires for purposes of light, power and traction). By L. W. Rosenthal. 93 pages. Price, \$2 net. New York: McGraw Publishing Co.

The chief mission of this book is to substitute a direct solution of calculating transmission lines for the trial method which was formerly a necessary evil. Within 93 pages the book contains an immense amount of formulas and tables.

The book contains six chapters, dealing, respectively, with direct-current distribution for light and power; distribution for direct-current railways; alternating-current transmission by overhead wires; alternating-current transmission by underground cables; interior wiring for alternating-current distribution, and distribution for single-phase railways.